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Needle-Mining Lepidoptera of Pine in North America

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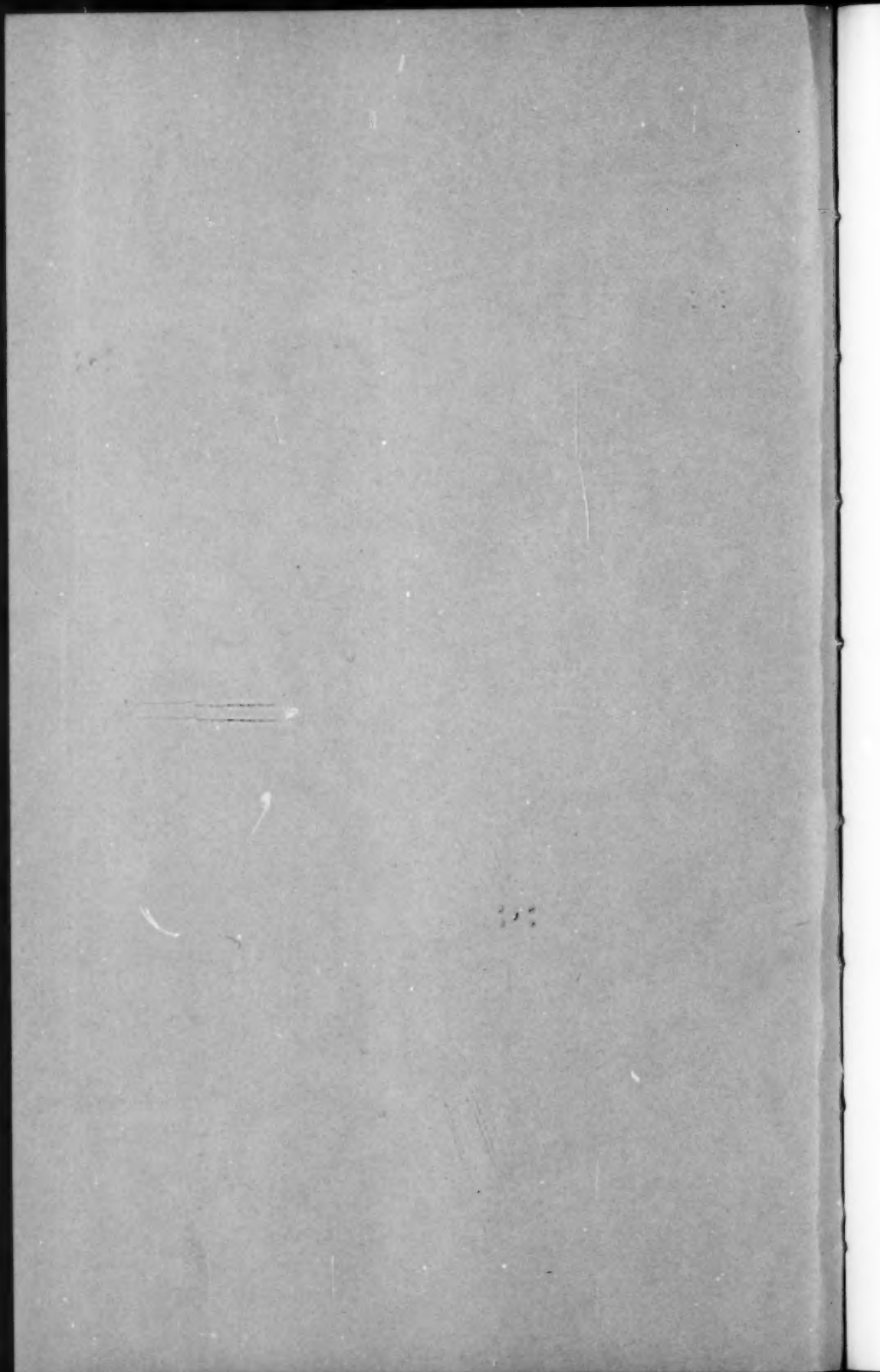
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THE CANADIAN ENTOMOLOGIST

Supplement 16

Accompanies Volume XCII, 1960



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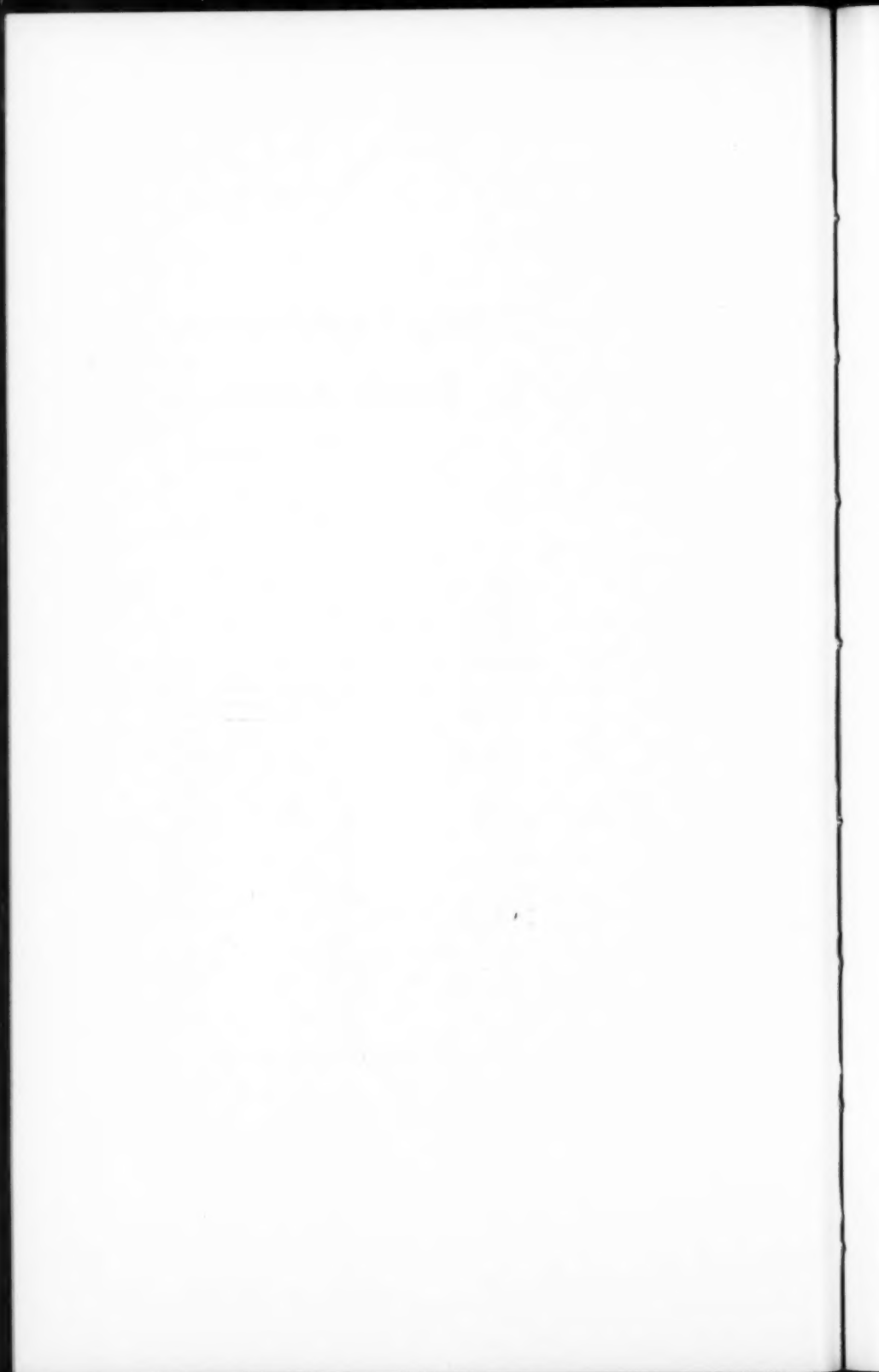
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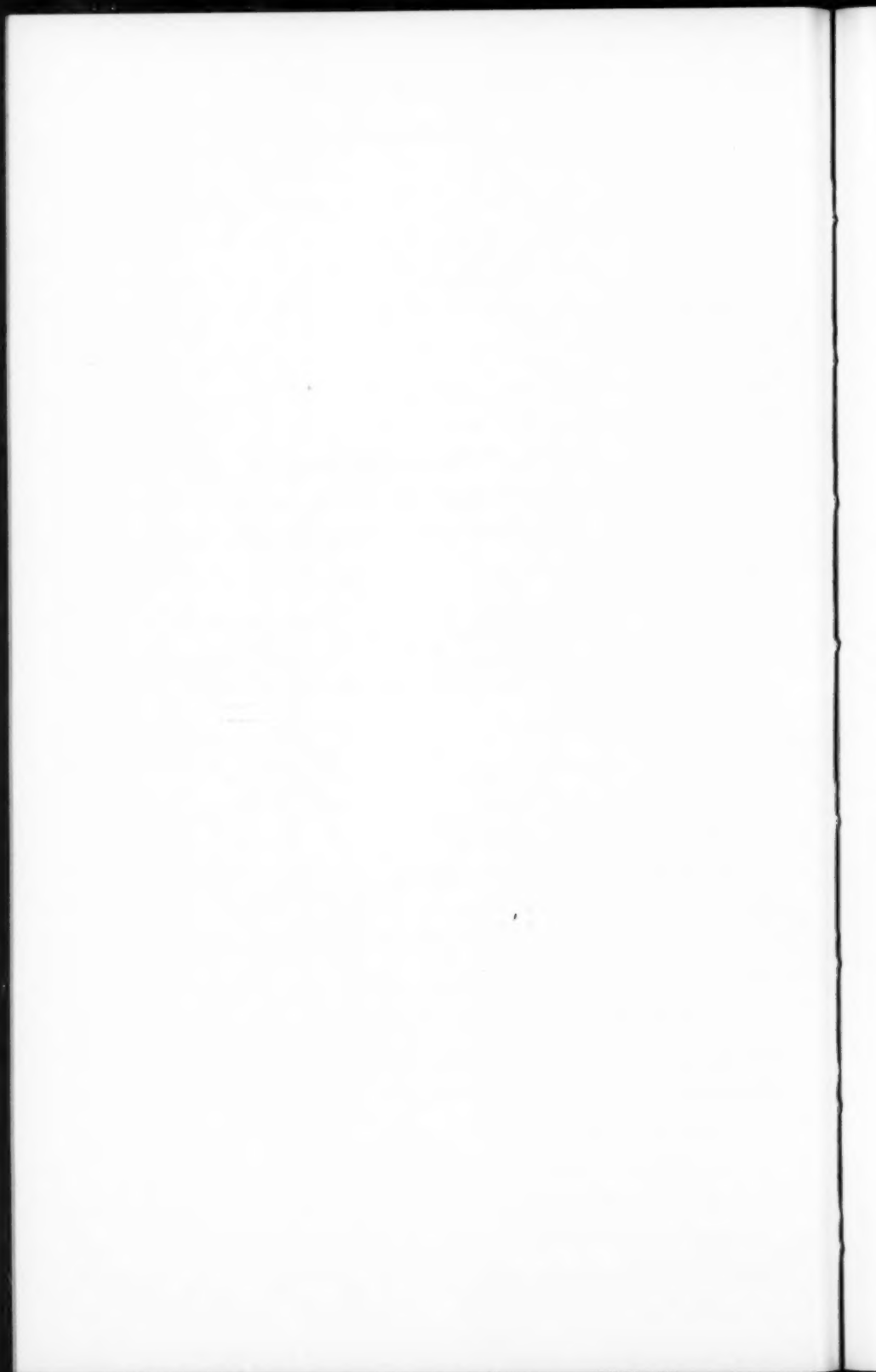
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Introduction

Lepidopterous needle miners have been pests of coniferous trees and shrubs in various regions of North America for many years. Several of the species mine the needles only during the early instars, and later either feed externally or bore into the buds, flowers, or new terminal growth. The majority spend their entire larval life within one or more needles and have an annual life cycle. Some of them require two years to complete the life cycle, and spend most of this time within the needles. Complete life-histories of several of the species have not been ascertained, and very little is known of the life-histories of most of the species described by the pioneer entomologists of North America.

The needle miners belong to the families Gelechiidae, Yponomeutidae, Olethreutidae, and Tortricidae. Most of the species belong to the Gelechiidae, and within this family the majority of them are related to, and for several years have been placed in, the genus *Recurvaria* Haworth. These are the species that present the major taxonomic problems because of the difficulty of recognizing the many sibling species that occur on various coniferous trees and shrubs.

The present paper deals mainly with the systematics of the adequately known pine-feeding species. However, much of the introductory part is concerned with the taxonomy of needle miners in general, and presents a background for this and future studies.

Acknowledgments

I wish to express my sincere gratitude to all, who made available for study, the historic lepidopterous collections in their charge. I am particularly grateful for the loan of specimens from Dr. J. F. Gates Clarke, United States National Museum, Washington, D.C.; Dr. A. B. Klots, American Museum of Natural History, New York, N.Y.; and Dr. W. L. Brown, Museum of Comparative Zoology, Cambridge, Mass. I also wish to thank the following officers of the Forest Biology Division, Research Branch, Canada Department of Agriculture, for supplying some of the life history data, and many specimens for study: Dr. M. L. Prebble, Director; Dr. B. M. McGugan, Associate Director, Ottawa, Ont.; Dr. R. W. Stark, Calgary, Alta.; Dr. D. A. Ross, Vernon, B.C.; and Mr. J. McLeod, Quebec City, Que. The assistance of Dr. E. M. Hering, West Berlin, Germany, for the kind donation of authentic European specimens is certainly appreciated. I am particularly grateful for the assistance of Mr. G. G. Lewis, Entomology Research Institute, Ottawa. He pinned and mounted most of the specimens, made the genitalic dissections, and assisted considerably in the life history observations. Finally, I wish to thank Mrs. Marion Platek, Biographic Unit, Research Branch, Ottawa, for preparing the drawings that accompany this paper.

Material Studied

This study was based mainly on specimens in the Canadian National Collection, Ottawa, Ont.; the United States National Museum, Washington, D.C.; the American Museum of Natural History, New York, N.Y.; and the Museum of Comparative Zoology, Cambridge, Mass.

The existing type specimens of the conifer needle-mining species described from North America have been studied to assist in determining their identity. North

American specimens of species believed to be of European origin have been compared with authentic European material. The study was based mainly on a few thousand reared specimens contained in the Canadian National Collection. The genitalic studies were based on the examination of approximately 600 dissections.

Historical Review

The first scientific description of a lepidopterous miner of conifer needles was made by the founder of the binomial system of nomenclature, Carl von Linné, of Sweden, in 1759 (Syst. Nat. p. 539). He proposed the name *Tinea dodecella*, now *Exoteleia dodecella* L., for a European species that was introduced into Canada many years later, and that mines the needles of Scots pine, *Pinus sylvestris* L. The first endemic North American species was described about a century later by the American pioneer microlepidopterist, Dr. Brackenridge Clemens, a physician of Eston, Pennsylvania. In 1860 (Proc. Phila. Acad. Sci. p. 165) he proposed the generic name *Evagora* for a single species that he named *apicitripunctella*. Although Clemens did not indicate the food plant, his species has for many years been interpreted as one that mines the needles of hemlock, and that is congeneric with some of the pine-needle miners.

Clemens died in 1867, and the study of Microlepidoptera in North America was continued by V. T. Chambers, a lawyer of Covington, Kentucky. Chambers described many North American genera and species, including the pine-needle-mining species *Exoteleia pinifoliella*, in 1880 (Jour. Cin. Soc. Nat. Hist. 2: 181).

In 1900 (Ent. News 11: 349) O. Dietz, New York, N.Y., proposed the generic name *Eucordylea* for a species he named *atruplicella*. He based this genus mainly on the very much expanded scale-tuft on the second joint of the male labial palpus (Fig. 28). The food plant of this species is not known, but the insect has congeners that feed on pine.

In 1902 H. G. Dyar, United States National Museum, Washington, D.C., (*A List of North American Lepidoptera*) placed *Evagora* Clem. as a synonym of *Recurvaria* Haworth, a generic name based on the European species *nanella* Hbn., which mines only in the early instars, in the leaves of hawthorn and apple.

During the first decade of the twentieth century, W. D. Kearfott, Montclair, New Jersey, described several species of gelechiid needle miners, and, following Dyar, placed them in the genus *Recurvaria*. Some of these were described from specimens reared not only by Dr. James Fletcher, Ottawa, Canada, the first Dominion Entomologist and Botanist, but also by his assistant at that time, Mr. A. Gibson, and by an ardent amateur collector, Mr. C. H. Young, who was a skilled preparator at the Canadian National Museum, Ottawa.

It is important, and should be recorded, that Kearfott worked with his collection and described new species in the evening using an electric light which cast a yellow glow. This fact is reflected in his descriptions of species, and such a light should be used for a critical comparison of specimens with his descriptions. If I may digress somewhat, Kearfott was a distributing agent for a plumbing and steam fitting company, and it is at least interesting to note that in a letter to Fletcher dated November 2, 1905, Kearfott wrote that he required "the services of a plumber pretty badly because of the recent addition of a new pup to his household".

During the first 20 years of the present century, a few needle-mining species from the southwestern United States were described by August Busck and Carl Heinrich, United States National Museum, Washington, D.C., and by Dr. Annette Braun, Cincinnati, Ohio. Following Dyar, they placed several of the gelechiid species in the genus *Recurvaria*. This generic assignment for most of the gelechiid needle-mining species, with the exception of *Eucordylea atruplicella* Dietz, was followed by Barnes and McDunnough in 1917 (*A Check List of the Lepidoptera of Boreal America*),

by Meyrick in 1925 (*in* Wytsman, Gen. Insect. Fasc. 184: 60), by Forbes in 1923 (*The Lepidoptera of New York and Neighboring States*), and by McDunnough in 1939 (*A Check List of the Lepidoptera of Canada and the United States of America*).

Prior to that of Freeman in 1957 (Pan. Pac. Ent. 33: 9), the last taxonomic work on the needle-mining species was by Heinrich in 1920 (Proc. U.S.N.M. 57: 65), in which he described *Recurvaria moreonella* from a single male, presumably reared from *Pinus ponderosa* Laws. var. *scopulorum* Engelm. in Colorado. Thus for a period of 37 years no additional descriptions or generic transfers of conifer needle-mining species were made.

During the last few years, studies on the needle miners have been resumed in Canada and in the western United States. However, most of this work was concerned with the biology and control of a few species of current economic importance.

Methods

As previously mentioned, lepidopterous needle miners have been recognized as being of significant economic importance in North America for several years. For an equal length of time the various forms have not been taxonomically understood. This was due in part to the general similarity of wing colour and pattern of the forms on various coniferous genera and species, to the complexity of structure, particularly in the asymmetrical male genitalia of some Gelechiidae, and to the difficulty of applying a specific name because of the loss or damage, or insufficient information on type specimens of the species and genera described by the pioneer lepidopterists, Clemens, Chambers, Kearfott, Busck, and others.

No attempt has been made to assemble a complete bibliography to the economic literature, largely because of the misidentifications involved, and the resultant impossibility of making correct nomenclatorial associations.

The problem was first approached by the usual method of comparative morphology of museum specimens. Early in the study it became evident that by this method the males of the various forms, and to a lesser extent the females, could be subdivided into four main categories: (1) those forms that differ from one another in wing colour and pattern, and in male genitalia; (2) those that could be recognized only by differences in the male genitalia; (3) those distinguished only by different wing colours and patterns; (4) the last category, and by far the largest, consisted of a heterogeneous confusion of more or less similarly marked forms with similar male genitalia, and with monophagous or heterophagous larval habits. For example, specimens reared from hemlock were partially distinguishable, on the basis of wing colour and pattern, from those on spruce. The latter, however, were almost indistinguishable morphologically from those reared from eastern white cedar, balsam fir, or from various species of pine. This suggested either a single, variable, heterophagous species, on the basis of morphology, or several sibling species with restricted food habits.

Observations on the life-histories of Lepidoptera have convinced me, that most, if not all, species may be recognized by their behaviour in any one or more of their metamorphic stadia, regardless of the anatomical similarities or dissimilarities. In every instance where closely allied species were intensively studied, the significant factor for their recognition was found in their behaviour. It is undoubtedly true that comparative morphology is the foundation of taxonomy, but in this and other insect groups, it can only be considered a basic prelude to taxonomic reality. The presence of many sibling species suggests that in the process of organic evolution, behaviour patterns often evolve prior to the anatomical alterations that inevitably follow, and help to define the biological units that comprise the present cross section of evolutionary development. Behaviour patterns, although more realistic taxonomically, are not exempt from the variation that exists in all taxonomic characters. These patterns are slowly changing in accord with the development of inorganic evolution, and, like any

other specific character, they must be evaluated and defined on the basis of discontinuous variation.

With this in mind, field studies were conducted on the needle miners to investigate larval behaviour and the type of mine that was constructed, with the belief that this approach would support or clarify the four categories outlined above.

These studies were conducted by making observations and collections of the various forms at frequent intervals during the larval and pupal stages. The collections were made by taking samples of the foliage containing the miners, and segregating them according to the food-plant species, the type of larval behaviour, and the resultant characteristics of the mine. The classified and isolated samples were placed in jelly jars, and the behaviour in confinement was compared with that in the natural environment. It was observed that unless a needle was acutely bent in the container, the mining habit in the rearing jar was similar to that exhibited in the needles on the trees. Some discordance was noted in the larval behaviour in the rearing jars and in nature among some of the species that do not spend all their larval life within the mine. In these instances, only the behaviour as it was observed in the natural environment was considered typical.

The studies clearly demonstrated that, regardless of the morphological similarities or dissimilarities, the various forms were readily distinguished by well-defined mining habits. These habits are considered to be the primary specific characters. They are supplemented by morphological attributes, and form the basis for the recognition of the needle-mining species.

The application of this criterion for the recognition of the species revealed a partial discordance within some of the monophagous forms of the second morphological category, those with similar wing colour and pattern, and dissimilar male genitalia. Within this category, the morphological division was made on the differences observed in the shape of the apical part of the tegumen, and the position of the anal armature, the hooks of the gnathos (Figs. 29, 30). The field studies demonstrated that this difference sometimes represented dimorphism of the male genitalia within some of the populations of some of the species. Normally (Fig. 29) the hooks of the gnathos are free and pendulous, and articulate at their bases with the base of the uncus. In the abnormal condition, the hooks are fused with the ventral wall of the uncus, and the apical portion of the tegumen is short and abnormally broad (Figs. 30, 39). This condition is present in 50 per cent of the males of *Evagora starki* Free. in some localities. This abnormality is also present in *E. milleri* Bsk. in California, in an unidentified species in Idaho, and in a species that feeds in the staminate flowers of red pine in Ontario (Fig. 39).

A somewhat similar condition also occurs in an unidentified species on white spruce in Quebec and Ontario. In this instance, the gnathos hooks lie against the ventral wall of the uncus, the tegumen is slightly folded upon itself, and the uncus appears to be peculiarly disfigured. In this case, if a dissecting needle is inserted to free the gnathos hooks from the uncus during the dissection of the genitalia, all the structures suddenly assume a normal, and considerably different appearance. The tegumen unfolds, and the uncus flips suddenly upward and backward.

It is interesting to note that these abnormal appearances are always of the same magnitude in each species where they are present. No structural gradation between the abnormal and the normal shape was observed. The causes of these physical defects lie well beyond the scope of this paper. They may be due to adverse environmental conditions, or to the lack of physical maturity.

Larval Behaviour

Although there are as many different patterns of larval behaviour as there are species, a few examples of behaviour types may help to illustrate this kind of specific

character. The mining habits of many species are complex, and there is some variation of habits within each species. For example, an entrance or exit hole may be cut on either the concave or the convex side of a needle. This appears to be due to the orientation of the needle with respect to sunlight or gravity. Some of the species enter a needle from the underside regardless of which surface of the needle is so oriented. Similarly an opening used for frass expulsion is often made on the underside of the needle where gravity assists with the housecleaning duties.

Regardless of the intraspecific variation of habits, the behaviour of each species follows a definite pattern, and the following types of gross behaviour will illustrate the specific characters. Some species leave all or part of the frass in the mine, others expel it. Some construct a silk ramp at the exit hole when the mine extends beyond it, to facilitate the moth emergence. Others construct silk tubes leading from one mined needle to another. A few make silk webs between the needles, often tying the needles together to form a tube. Some line the inside of the mine with silk, and some spin no silk at all.

The duration of the larval life varies among the species from a few weeks to almost two years. Many of the species spend their entire larval lives within the needle; others leave the needle at various stages of development to bore into the staminate flowers or developing buds, or to feed externally. Some pupate in the mine, others in various locations beyond the mine. Pupation usually occurs in early summer, but some pupate in the fall. A combination or subdivision of these types of behaviour can be used to identify the species. The larval behaviour of each species, if known, is included in the taxonomic descriptions.

The Male Genitalia

The male genitalia are derived from the modified ninth, tenth, and eleventh abdominal segments (See Fig. 29 for most of the parts). In the needle-mining species, the uncus is usually a prominent, dorsal, terminal structure. It is either roof-like or shallowly bilobed (Fig. 29), subconical (Fig. 42), elongated (Fig. 44), trifid (Fig. 43), bifid (Fig. 48) or spoon-like (Fig. 47).

The gnathos, if present, arises from the ventral surface near the base of the uncus. It is represented by a single, articulating, hook-like appendage in the midventral line (Fig. 43), or two or three such appendages (Figs. 53, 29). In the genus *Argyresthia*, the gnathos consists of two pendulous lobes covered with specialized scales (Fig. 49).

The tegumen is a dorsal structure joined to the uncus. It is usually shaped like an inverted U, each arm of which is extended to articulate with the vinculum (Fig. 53). The dorso-lateral portions of the tegumen are extended into asymmetrical flap-like projections in some of the Gelechiidae (Fig. 29).

The vinculum, in its simplest form, is a U-shaped structure, sometimes extended anteriorly and ventrally into an elongate saccus (Fig. 52). In some of the species of Yponomeutidae, the ventral profile of the vinculum and tegumen is obovate (Fig. 51), or subrectangular (Fig. 52). In some gelechiids, the vinculum is acutely angled with the tegumen, and considerably modified. It is extended posteriorly into two somewhat asymmetrical digitate sicae (Fig. 29), or produced into three pairs of processes (Fig. 46).

The claspers articulate at their bases with the inner ventral margins of the vinculum. In most Lepidoptera these structures are the main clasping organs of the male during copulation. They usually consist of a pair of large, flattened, double-walled lobes, slightly tapering and bluntly rounded apically (Fig. 53). In some of the gelechiid genera, the claspers are tubular and taper toward their apices. In other genera, such as *Evagora* and *Eucordylea*, the tubular claspers are twisted and asymmetrical, the left one being considerably atrophied (Fig. 30). In these genera it appears that the claspers

are not the main clasping organs, this function apparently being performed by the very specialized vinculum and tegumen.

The aedeagus is tubular, short, thick, and arcuate in *Evagora* (Fig. 30), *Eucordylea*, *Argyrotaenia*, and *Epinotia*; very long and tubular in the yponomeutid genera *Argyresthia*, *Ocnerostoma*, and *Zelleria* (Figs. 48-52); or with apical armature, and a very long basal pouch in the gelechiid genus *Chionodes* (Fig. 47).

The juxta serves as a fulcrum for the aedeagus and is associated with the vinculum, or with the clasper bases (Fig. 54).

The transtilla, if present, connects the dorsal bases of the claspers (Fig. 53).

The eighth abdominal segment is modified in many gelechiids and yponomeutids into a pair of flap-like structures surrounding the genitalia (Fig. 48). This segment may also contain a pair of coremata, that are pouches containing hair-pencils (Fig. 49), and also a Y- or V-shaped sclerite, the furcula (Fig. 49).

Key to the Genera on the Basis of the Male Genitalia

1. Uncus bifurcate (Fig. 48) 2
Uncus not bifurcate 4
2. Gnathos with two widely separated, finger-like processes. Clasper scimitered.
Saccus not elongated (Fig. 54) p. 64 *Epinotia* Hbn. 3
Gnathos atrophied. Saccus elongated (Fig. 52) 3
3. Coremata reduced. Eighth segment divided forming two lobes that enclose the
genitalia. Clasper elongated (Fig. 48) p. 55 *Zelleria* Staint. 3
Coremata well developed. Eighth segment normal. Clasper broad (Fig. 51) p. 57 *Ocnerostoma* Zell. 3
4. Uncus long, finger-like. Gnathos arms fused at their apices to form a hook (Fig.
53) p. 66 *Argyrotaenia* Steph. 5
Uncus and gnathos not as above 5
5. Clasper broad. Gnathos covered with specialized scales. Eighth abdominal venter
with a furcula (Fig. 49) p. 60 *Argyresthia* Hbn. 6
Clasper thread-like, tapered from base. Gnathos and eighth segment not as above 6
6. Claspers symmetrical (Fig. 45) 7
Claspers asymmetrical (Fig. 30) 8
7. Aedeagus with a very long basal pouch and with apical armature (Fig. 47) p. 53 *Chionodes* Hbn. 6
Aedeagus short, without basal pouch or apical armature. Vinculum produced
anteriorly into a pair of curved sicae (Fig. 45) p. 48 *Exoteleia* Wlgn. 6
8. Uncus roof-like, shallowly bilobed apically (Fig. 29), or subconical with three
gnathos hooks (Fig. 42), or trifid (Fig. 43) p. 20 *Evagora* Clem. 6
Uncus elongated, with coarse lateral hairs (Fig. 44), and a single, long, gnathos hook
..... p. 47 *Eucordylea* Dietz 6

Key to the Species on the Basis of Adult Characters

1. Vertex of head with long, rough, hair-like scales (Fig. 27) 2
Vertex with short scales (Fig. 26) or smooth (Fig. 25) 7
2. Forewing golden brown, with a distinct, median, longitudinal, white fascia extending
from the base almost to the apex 16. *Zelleria hainbachii* Bsk. 3
Forewing not as above 3
3. Forewing golden yellow, with a faint, transverse, white fascia at the apical one-
quarter 15. *Chionodes retiniella* Barnes and Bsk. 4
Forewing not as above 4
4. Forewing white or yellowish-white without markings 5
Forewing light brownish-grey 20. *Argyresthia pilatella* Brn. 5
5. Labial palpus moderately long, porrect, slightly curved 19. *Argyresthia flexilis*, new species 6
Labial palpus obsolete 6
6. Wingspread 11-13 mm. 18. *Ocnerostoma pinariellum* Zell. 6
Wingspread 8-9 mm. 17. *Ocnerostoma strobfiorum* n. sp. 6
7. Forewing golden brown with three almost equidistant, transverse, white fasciae 13. *Exoteleia pinifoliella* Kft. 6
Forewing not as above 8

8. Forewing with reddish-brown transverse bands 9
Forewing not as above 10
9. The reddish-brown bands of forewing with dark margins 22. *Argyrotaenia tabulana* Free.
Reddish-brown bands of forewing without dark margins 23. *Argyrotaenia pinatubana* Kfr.
10. Forewing with basal third dark grey; outer two-thirds whitish. Hind wing broad, much wider than the fringe 21. *Epinotia aridos*, new species
Forewing purplish, greyish, or whitish, with black spots or white streaks. Hind wing lanceolate, with fringe much longer than width of wing 11
11. Forewing grey, with a broad, indistinct, transverse band at the outer two-thirds. Male genitalia with claspers bilaterally symmetrical (Fig. 46) 14. *Exoteleia dodecella* Linn.
Forewing not as above. Claspers of male bilaterally asymmetrical (Fig. 30) 12
12. Forewing almost uniformly purplish-grey 2. *Evagora pinella* Bsk.
Forewing not as above 13
13. Forewing greyish, with a median, longitudinal, white streak from base to near apex. Described from Colorado 8. *Evagora moreonella* Heinr.
Forewing not as above 14
14. Uncus of male hemispherical with basal, lateral bristles. Caudo-lateral projections of male tegumen absent (Fig. 42) 11. *Evagora coniferella* Kfr.
Uncus of male shallowly bilobed apically (Fig. 29) or trifid (Fig. 43) or subconical (Fig. 42) *Evagora* spp.
(See key to species on the basis of behaviour).

Key to the Species on the Basis of Behaviour of Immature Stages

1. Mine containing frass (Fig. 56) 2
Mine not containing frass (Fig. 57) 6
2. Large exit hole with silken ramp at middle of mine. Pupa in the mine below exit hole (Fig. 56) 4. *Evagora ardas*, new species
Exit hole at base of mine without silken ramp 3
3. Pupation in mine 13. *Exoteleia pinifoliella* Kfr.
Pupation not in mine 4
4. Pupation in bud. Mine in apical half of needle 14. *Exoteleia dodecella* L.
Pupation in a bundle of needles tied together. Mine occupying most of needle 5
5. Mine purple. On *Pinus contorta* Dougl. var. *latifolia* Engelm. 18. *Ocnorostoma piniariellum* Zell.
Mine grey. On *Pinus strobus* L. 17. *Ocnorostoma strobivorum*, new species
6. Pupation within the mine 7
Pupation not in the mine 10
7. One hole only in mine at base. Empty pupal case protruding from hole after moth emergence 21. *Epinotia aridos*, new species
More than one hole in mine 8
8. Entrance hole above exit (Fig. 57) 3. *Evagora biopes*, new species
Entrance hole below exit (Fig. 55) 9
9. Hole at base of mine with webbing and frass between needles (Fig. 58) 7. *Evagora milleri* Bsk.
No hole at base of mine. No webbing between needles (Fig. 55) 1. *Evagora starki* Free.
10. Mined and adjacent needles webbed together to form a bundle or tube 11
Mined and adjacent needles not tied together to form a bundle 15
11. Apices of needles of bundle eaten off (Fig. 69c). On *Pinus strobus* L. 23. *Argyrotaenia pinatubana* Kfr.
Apices of needles of bundle not eaten off 12
12. Bundle abundantly lined inwardly with frass (Fig. 59). On *Pinus flexilis* James 5. *Evagora lewisii*, new species
Bundle not lined inwardly with frass 13
13. Pupa not in the bundle. On *Pinus banksiana* Lamb., *P. contorta* Dougl. var. *latifolia* Engelm., and *P. ponderosa* Laws. 22. *Argyrotaenia tabulana* Free.
Pupa in the bundle 14
14. Pupa in a dense white cocoon (Fig. 67). On *Pinus flexilis* James 19. *Argyresthia flexilis*, new species
Pupa mainly naked (Fig. 65). On *Pinus ponderosa* Laws. 15. *Chionodes retiniella* B. and Bsk.

15. Needles mined only at base within the needle sheath..... 16. *Zelleria haimbachii* Bsk.
 Needles mined above the needle sheath 16
 16. No silk tube or web extending from the mine entrance 20. *Argyresthia pilatella* Brn.
 Silk tube or web extending from the mine entrance 17
 17. Silk extending from mine entrance, broad, tentiform, and densely covered with frass.
 Pupation in mid-July. On *Pinus contorta* Dougl. var. *latifolia* Engelm. 9. *Evagora florum*, new species
 Silk tube narrow, short, extending from mine entrance to adjacent unmined needle.
 None or only a few frass pellets adhering to the tube. Two or three mine
 entrances in a single needle. Pupation in late May. On *Pinus resinosa* Ait.
 6. *Evagora resinosa*, new species

Gelechiidae

Evagora Clemens

Evagora Clem., 1860, Proc. Phila. Acad. Sci. p. 165.

The name *Evagora* is here applied to all the pine needle-mining species that were formerly placed in the genus *Recurvaria* Haworth. Busck (1929, Proc. Ent. Soc. Wash. 31: 15.) suggested, that, because of differences in the male genitalia between North American species and the European *nanella* Hbn., the type species of *Recurvaria*, it may be necessary to resurrect one of the North American generic names which are synonymized with *Recurvaria*. This view was supported by Freeman (1957, Pan-Pac. Ent. 33: 12). Continued study has shown that this suggestion was well founded. Therefore, the oldest applicable generic name *Evagora* is utilized. When the taxonomy of this group is further advanced, it may be found that additional generic divisions will be required for an adequate definition of the species groups.

1. *Evagora starki* Freeman, new combination

Fig. 1

Recurvaria milleri auct. nec Bsk. in part; Hopping, 1945, Proc. Ent. Soc. British Columbia, 42: 1-2.

McLeod, 1951, Can. Ent. 83: 295-301.

Recurvaria sp., Stark, 1954 Can. Ent. 86: 1-12.

Recurvaria starki Freeman, 1957, Pan-Pac. Ent. 33: 9.

Antenna alternately marked with ochreous-white and black bands. Palpus rather short, not tufted in the male. Second joint of palpus whitish inwardly, ochreous-fuscous outwardly; third joint white with ochreous-fuscous base. Face and vertex shining white. Thorax and forewing light grey, the latter with somewhat obscure blackish patches crossing the wing at the basal third, at the outer two-thirds, and near the apex; the postmedian band bordered outwardly with white, and sharply angled outwardly at its middle. The patch near the apex extending obliquely inward almost to the posterior margin. Apex of wing mostly dark, with obscure, white spots at apex. Hind wing pale smoky. Fringes of all the wings shiny, light, ochreous-grey. Under surfaces of all the wings dull white. Male with a long, ochreous hair-pencil arising from beneath the anal angle at the base of the hind wing. Fore and mid tibiae and tarsi alternately banded with black and white scales. Hind tibia whitish, with long hairs above. Each segment of hind tarsus grey, with a white tip. Wingspread: 12-13 mm. Moth in the latter part of July, requiring two years to complete the life cycle.

Male genitalia (Fig. 29)—Uncus roof-like. Gnathos with three pendulous, hook-like processes, the median one slightly the longest. Tegumen dimorphic; normally longer than wide (Fig. 29); abnormally very much broader, and with the gnathos hooks fused to the ventral wall of the uncus (Fig. 30). Caudo-lateral projections of tegumen asymmetrical, flap-like. Claspers asymmetrical, tubular, twisted; the right clasper much larger than the left. Aedeagus pistol-shaped. Vinculum produced apically into two somewhat asymmetrical hook-like sicae.

Type.—In the Canadian National Collection.

Type locality.—Mt. Eisenhower (near Banff), Alberta.

Distribution.—Southeastern British Columbia; southwestern Alberta; northwestern Montana; Cypress Hills, Saskatchewan.

Food plant.—*Pinus contorta* Dougl. var. *latifolia* Engelm., lodgepole pine.

Behaviour (Fig. 55).—The early-instar mine is made at the needle tip and is difficult to see. The young larva enters the needle below the apex and mines upward. The third instar mine is located at the apical end of the needle (Fig. 55a). The larva enters near the apex and mines toward the tip, leaving some frass in the base of the mine. The larva leaves this mine and enters another needle near its middle. It mines upward using the entrance hole to eject the frass. Near the needle tip a large moth exit hole is made, often on the side of the needle opposite the entrance hole. This large apical hole is now used for the ejection of frass. The larva then mines downward, below the entrance hole. Before pupation, the larva seals the small entrance hole with silk. It pupates in the mine facing the exit hole, but below the entrance hole (Fig. 55b). Upon emergence, the moth leaves the pupal case and crawls to the exit. The larval period of this species is approximately 21 months. These observations were made from topotypical material with the assistance of Dr. R. W. Stark.

Remarks.—This species is closely allied to *E. milleri* Bsk. from which it may be distinguished by the grey colour of the forewing, and the larval behaviour. It is a pest of lodgepole pine in southwestern Alberta.

2. *Evagora pinella* Busck, new combination

Fig. 7

Recurvaria pinella Bsk., 1906, Can. Ent. 38: 121.

This species is known only from the type material, which is somewhat faded. I, therefore, quote the original description:

"Antennae dark purple, with silvery-white annulations. Second joint of labial palpi black, with apex and a large spot on the inner side silvery white; terminal joint white, with a narrow black annulation on basal half. Face white, iridescent, sprinkled with darker scales. Vertex and thorax dark purple. Fore wings dark purple, sparsely sprinkled with lighter scales. From basal fourth of costa to basal third of the dorsal edge is a thin, very indistinct and ill-defined oblique white fascia. Along the dorsal edge below the fold are two or three very small tufts of black and white raised scales. Cilia dark purple, apical part with a still darker blackish basal line along the edge of the wing. Hind wings light fuscous; cilia yellowish. Abdomen bronzy fuscous; female with protruding horny, hairy ovipositor. Legs purplish black, with white bars; tarsal joints tipped with white.

"Alar expanse: 9-10 mm.

"Food-plant: *Pinus ponderosa* Laws.

"Habitat: Manitou, Colorado, Prof. C. P. Gillette. U.S.N.M. Type No. 9811.

"The larva mines the leaves of *Pinus ponderosa* exactly in the fashion of the common *Paralechia pinifoliella* Chambers, in the Eastern States, and is, according to Prof. Gillette, of some economic importance.

"Prof. Gillette, who has shown me beautiful drawings of this insect and its work, will shortly give a fuller life-history.

"In coloration the species comes nearest to *Recurvaria nigra* Busck, but that species has the thin cross line at apical third of the fore wing instead of at basal third as in the present species. Venation and oral characters typical."

Male genitalia (Fig. 31, of paratype).—Uncus roof-like, shallowly bilobed apically. Ganthos with three hook-like processes, the median one much the longest. Caudo-

lateral projections of the tegumen asymmetrical, the left one much larger and with arcuate lateral margin. Claspers asymmetrical, tubular, twisted; the right one much larger and with hooked apex. Sicae of vinculum obtusely angled.

Type.—In the United States National Museum.

Type locality.—Manitou, Colorado.

Distribution.—Known only from the type locality.

Food plant.—*Pinus ponderosa* Laws, ponderosa pine.

Behaviour.—Busck stated that the larva mines in a manner similar to that of *Exoteleia pinifoliella* Chamb.

Remarks.—This species is known only from the type material. The dark-purple colour of the moth is the best character for its recognition.

3. *Evagora biopes*, new species

Fig. 4

Antenna alternately marked with black and ochreous bands. Palpus shining white; second joint marked with black spots beneath; terminal joint with a black band near base. Face and vertex shining white, the vertex with fuscous scales laterally. Thorax shining black. Forewing white with numerous black scales arranged as follows: an elongate, black, basal, costal spot; an indistinct, transverse, antemedial, black band, the posterior portion appearing as a fairly distinct black spot in the fold; a similarly marked postmedial band; apical portion of wing black, containing a black dot surrounded by white scales near apex; apical fringe white, flecked with dark fuscous; posterior fringe silvery grey. Hind wing light grey; fringe silvery grey. Male with a long, ochreous, hair tuft extending from beneath the base of the hind wing. Legs and tarsi white, banded with shiny black. Wingspread 13-14 mm. Moth in mid-July.

Male genitalia (Fig. 33 of holotype).—Uncus roof-like; shallowly bilobed apically. Gnathos with three hook-like processes, the median one much the longest. Caudolateral projections of tegumen asymmetrical, flap-like, opposite, the left one larger. Claspers asymmetrical, tubular, twisted; the right one much larger than the left. Vinculum produced apically into two somewhat asymmetrical, curved sicae.

Holotype.—Male, Cypress Hills Provincial Park, Saskatchewan, July 17, 1958 (Freeman and Lewis). Reared from *Pinus contorta* Dougl. var. *latifolia* Engelm. No. 6841 in the Canadian National Collection, Ottawa. *Paratypes*.—Three females, same locality and rearing data as holotype. July 11, 16, and 17, 1958.

Distribution.—Known only from the Cypress Hills Provincial Park, Saskatchewan.

Food Plant.—*Pinus contorta* Dougl. var. *latifolia* Engelm., lodgepole pine.

Behaviour. (Fig. 57).—The late-instar larva enters the needle near the tip and mines almost to the base. All frass is ejected through the entrance hole, which is lined with a silk ramp. Prior to pupation, the larva cuts a large moth-exit hole just below the entrance hole and often on the opposite side of the needle. This exit hole is also lined with a silk ramp to facilitate the moth emergence. Pupation occurs in the mine near the base of the needle, the pupa facing toward the exit hole. These observations were made from the type material.

Remarks.—The moth of this species closely resembles that of *E. starki* Free., with which it was sympatric in the Cypress Hills. The mining habits afford the best means of recognition.

4. *Evagora ardas*, new species

Fig. 3

Antenna alternately marked with white and fuscous bands. Second joint of palpus white, with a few fuscous scales at base and on under side; terminal joint white, with

a black ring near base. Face white; vertex white, speckled with fuscous. Thorax and forewing white, sprinkled with black scales and spots. Forewing with a small black spot at base and three other ones along the fold, the outer one the largest and situated near the trailing edge at the outer two-thirds; an elongate black antemedial costal spot; near the apex is a large white costal blotch extending as a curving spur of white scales terminating in a white spot immediately anterior to the outer black spot on the fold. Without magnification, this gives the impression of an outwardly angled fascia. Apex of wing white with a few indistinct small black spots; fringe whitish-ochreous. Hind wing whitish, with slightly ochreous fringe. Male with a long ochreous hair tuft extending posteriorly from beneath base of hind wing. Fore- and mid-leg and tarsus black, banded with white. Hind leg shining white; tarsus with black bands. Wingspread: 13-13.5 mm. Moth in late June.

Male genitalia (Fig. 32).—Uncus roof-like. Gnathos with three hook-like processes, the median one much the longest. Caudo-lateral projections of tegumen asymmetrical, flap-like opposite; the left one larger. Claspers asymmetrical, tubular, twisted; the right clasper much larger than the left. Vinculum produced apically into two angled digitate sicae, the right one larger. Similar to *E. milleri* Bsk., *E. moreonella* Heinr., and *E. starki* Free.

Holotype.—Male, East Glacier, Montana, June 29, 1958 (Freeman and Lewis). Reared from *Pinus contorta* Dougl. var. *latifolia* Engelm. No. 6842 in the Canadian National Collection, Ottawa. *Paratype*.—Male, June 30, 1958, otherwise the same data as above.

Distribution.—Known only from East Glacier, Montana.

Food plant.—*Pinus contorta* Dougl. var. *latifolia* Engelm., lodgepole pine.

Behaviour (Fig. 56).—The mined needle contains frass only above the large silk-ramped exit hole. The frass is particularly dense toward the apex. The larva enters the needle near the tip and mines downward, cutting two to four openings, and usually spinning silk over the entrance hole. The last and largest opening is often situated near the middle of the needle, and the larva mines downward, usually to the needle base.

Prior to pupation, a silken ramp is constructed at the large opening to expedite the moth emergence. Pupation occurs in the mine below the exit hole. These observations were made from the type material.

Remarks.—The presence of frass in the mine and the characteristics of the mine are the best means of recognizing this species. The moth closely resembles that of *E. starki* Free. It was sympatric with *starki* at East Glacier, Montana.

5. *Evagora lewisi*, new species

Fig. 8

Antenna alternately marked with black and white bands. Palpus with second joint marked with black and white bands; apical joint white, with a black ring at base. Face and vertex shining white, with a few fuscous scales laterally. Thorax white with a few black scales. Forewing white with scattered black scales and rather distinct black bands; a black transverse band on the basal one-quarter extending obliquely outward toward the trailing margin; several white scales at the wing base; an antemedial black band giving off a median black dash extending outward to between a postmedial black costal spot and a postmedial black posterior spot; apical one-quarter black with a few white scales; extreme apex white, containing a central black spot. Apical fringe fuscous with scales white-tipped; posterior fringe silvery grey. Hind wing light grey; fringe silvery grey. Male with a long ochreous hair-tuft extending from beneath base of hind wing. Legs white with black bands; hind femora cream-coloured above. Wingspread: 10.5-12.5 mm. Moth in early July.

Male genitalia (Fig. 34, of paratype).—Uncus roof-like; bilobed apically. Gnathos with three hook-like processes, the median one much the longest. Caudo-lateral flap-like projections of the tegumen asymmetrical, the left one much the larger. Claspers asymmetrical, tubular, twisted; the right one much larger. Vinculum produced apically into two curved, digitate sicae.

Holotype.—Male, Cowley, Alberta, July 3, 1958 (Freeman and Lewis). Reared from *Pinus flexilis* James. No. 6843 in the Canadian National Collection, Ottawa. *Paratypes*.—One male and seven females, same locality, food plant, and type number. Male, July 8, 1958. Females, one, July 3; one, July 6; two, July 8; two, July 11; one, July 14, 1958.

Distribution.—Known only from Cowley, Alta., at high elevation where *Pinus flexilis* occurs.

Food plant.—*Pinus flexilis* James, limber pine.

Behaviour (Fig. 59).—The larva mines the central or apical half of three or four needles, and ties the five needles into a bundle. The larva mines toward the apex of the needle, ejecting the frass through the entrance or other hole cut on the inside of the needle. Thus the middle of the bundle eventually becomes full of frass, held together with silk strands or webbing. As the larva mines, it cuts a new hole farther along for frass ejection, and each subsequent mine in a new needle is usually made more apically in the needle to allow for frass ejection on top of the frass column already existing. Pupation occurs within the bundle, outside the mines, in some silk webbing at the apical end of the frass column. These observations were made from the type material. In Fig. 59, one needle has been removed from the bundle to show the type of mine, frass column and position of the pupa.

Remarks.—This species belongs in the *milleri-starki* group. It is readily distinguished by the larval behaviour and the contrasting maculation of the forewing. It is named in honour of Mr. G. G. Lewis who has assisted considerably in the rearing, and in the technical aspects of the needle-miner work.

6. *Evagora resinosa*, new species

Fig. 2

Antenna alternately marked with black and whitish bands. Palpus with second joint black below, white above; terminal joint white with a black basal band, and usually with a black tip. Face ivory-white with a few lateral, grey scales. Vertex white, often with a mixture of light fuscous scales, more abundant laterally. Thorax with a mixture of black and white scales. Forewing black, with a sprinkling of white scales; a black median spot at the basal one-quarter; an antemedial black costal spot and an antemedial black spot in the fold; a postmedial, outwardly angled, white, transverse fascia, sometimes incomplete; apex whitish, with a small central black spot; apical fringe grey, the scales with white tips; trailing fringe light grey. Hind wing and fringe grey. Male with a long ochreous hair-tuft extending from beneath the base of the hind wing. Fore- and mid-legs and tarsi with black and white bands. Hind leg with creamy-white tibia, and with black- and white-banded femur and tarsus. Wingspread: 11-11.5 mm. Moth in the latter half of June and early July.

Male genitalia (Fig. 35, of paratype).—Uncus roof-like, bilobed apically. Gnathos with three hook-like processes, the median one much the longest. Caudo-lateral projections of the tegumen asymmetrical, the left lobe very strongly developed, broadly arcuate. Claspers asymmetrical, the right one much larger. Vinculum produced apically into two, asymmetrical, digitate, strongly recurved sicae.

Holotype.—Male, North Bay, Ontario, June 25, 1958. Reared from *Pinus resinosa* Ait. Forest Insect Survey No. S58-0708-01. No. 6844 in the Canadian National Collection, Ottawa. *Paratypes*.—Six males, two females, North Bay, Ont., June 23-27,

1958; three males, one female, Monerville, Ont., June 17-24, 1958; four males, one female, Temagami, Ont., June 2-18, 1958; one male, Diver, Ont., Dec. 23, 1958 (reared in laboratory); one male, one female, Marten River, Ont., June 17, 1958; one male, Callander, Ont., June 17, 1958; one male, one female, Goward, Ont., June 24, 28, 1958; one male, Little Rapids, Ont., June 17, 1958; one female, Trout Creek, Ont., July 3, 1958; one female, Haileybury, Ont., June 17, 1958; two females, Kynock, Ont., July 5, 7, 1958; one female, Whitefish Falls, Ont., July 11, 1958; one female, Vickers Heights (near Ft. William), Ont., June 23, 1958. All paratypes reared from *Pinus resinosa* (Forest Insect Survey).

Distribution.—Known only from the region around North Bay and Ft. William, Ont.

Food plant.—*Pinus resinosa* Ait., red pine.

Behaviour (Fig. 60).—Late-instar larvae enter the inner surface of the needle and mine toward the tip. A short, flimsy, silk tube is constructed around the entrance hole, and is attached to the inner side of the adjacent unmined needle. The frass is ejected from the mine, at first through the entrance hole and later through one or two other holes cut usually on the outer surface of the needle, above the entrance hole. These last holes are not covered with silk and the larva leaves the mine for pupation in late May. In the rearing jars, the larvae spun a white, rather dense cocoon on the twigs and on the sides of the jar. Pupation in the field was not observed. These observations were made from the type material.

Remarks.—This species may be recognized by the mining habits, and by the broad, arcuate lobe of the tegumen of the male genitalia. Officers of the Forest Insect Survey have also reared specimens, presumably of this species, from red pine at River Valley, a locality near North Bay. An examination of the male genitalia of nine of their specimens showed that two of them had remarkably different genitalia. The tegumen and lateral lobes are misshapen, the vinculum and sicae are directed anteriorly, and the claspers are absent. The significance of this condition is not known.

7. *Evagora milleri* Busek, new combination

Fig. 9

Recurvaria milleri Bsk., 1914, Proc. Ent. Soc. Wash. 16: 144.

Recurvaria milleri Bsk., Patterson, 1921, Jour. Agr. Res. 21: 127.

Recurvaria milleri Bsk., Samuelson, 1954, Lep. News 8: 91.

Antenna white, annulated with black. Palpus white, with black scales at the base of the second joint outwardly; apical joint annulated with black near base. Legs white with black bands, particularly on the tibia. Head and thorax white, sparsely covered with fuscous scales. Forewing white with numerous black spots and dashes; an elongate black dash at the base of costa; an irregular black patch on costa beyond middle; an elongate black dash in the cell; the wing generally sprinkled with black-tipped scales. Fringe silvery-grey. Hind wing light fuscous, with silvery-grey fringes. Wingspread: 12-15 mm. Moth in mid July, requiring two years to complete its life cycle.

Male genitalia (Fig. 36, of paratype).—Uncus roof-like. Gnathos with three pendulous, hook-like processes, the median one slightly the longest. Tegumen dimorphic; normally longer than wide (Fig. 36); abnormally very much broader, and with the gnathos hooks fused to the ventral wall of the uncus. Caudo-lateral projections of tegumen asymmetrical, flap-like. Claspers asymmetrical, tubular, twisted; the right clasper much larger than the left. Aedeagus pistol-shaped. Vinculum produced apically into two somewhat asymmetrical, hook-like sicae.

Type.—In the United States National Museum.

Type locality.—Yosemite National Park, California.

Distribution.—Known to the writer only from the Yosemite and Sequoia National Parks, California.

Food plant.—*Pinus contorta* Dougl. var. *murrayana* Engelm., lodgepole pine.

Behaviour.—The late-instar larva usually mines two adjacent needles (Fig. 58). It webs two needles together near the basal quarter of the needles and mines upward in one, ejecting the frass from the entrance hole. Some of the frass adheres to the webbing. The larva then mines into the second needle under the web, and again mines upward to the tip, again ejecting frass into the webbing at the entrance hole. At maturity, a large, moth-exit hole is made near the tip of the needle (Fig. 58a), and a silk ramp is constructed to facilitate the exit of the moth. The ramp insures that the moth does not crawl beyond and find itself trapped in the blind end of the mine. Silk is spun over the entrance hole and over a smaller hole that rarely is present between the entrance hole and the moth exit hole (Fig. 58b). Pupation occurs in the mine below the exit. Upon emergence the moth crawls from the pupal case, along the mine to the exit. Approximately 18 months are spent in the larval stage. The description of the larval behaviour has been based on material from the Sequoia National Park, Calif.

Remarks.—This species is a pest of lodgepole pine in California. The moth is white with black spots and dashes.

8. *Evagora moreonella* Heinrich, new combination

Recurvaria moreonella Heinr., 1920, Proc. U.S. Nat. Mus. 57: 65.

The type of this species is somewhat faded. I therefore, quote the original description:

"Antennae grayish fuscous, banded with black above. Palpi white overlaid with black; second joint black except for a white streak along the upper inner side and a ring of white scales at extremity; terminal joint white with a broad black band near base and another near the tip. Face white, with a narrow border of black scales on either side. Head white with admixture of blackish scales. Thorax and fore wings white densely overlaid with black. On basal third of fore wing below the cell a short sinuate, longitudinal line of black scales; beneath this a small raised patch of white scales; another small black patch on outer third of dorsum; above this and extending from the end of the sub-basal black streak to middle of terminal third of wing and terminating in a short hook to dorsum a narrow irregular line of white scales; a faint shading of black scales near tornus; along apical third of costal fourth, and along termen, three black dots inwardly edged with white; cilia dark grayish fuscous. Hind wings smoky fuscous; cilia slightly paler. Legs black with tibial and tarsal extremities white, except hind tibiae which are white with large patches of blackish scales. Alar expanse: 13.5 mm. Male genitalia of type figured.

"*Habitat.*—Cheyenne Mountain, Colorado. (G. Hofer).

"*Food plant.*—*Pinus scopulorum*. A single male reared under Hopk. U.S. No. 13957b-2. Moth issued July 7, 1916. Habits of the larva not noted, probably a needle miner.

"*Type.*—Cat. No. 21808, U.S.N.M.

"Close to *Recurvaria milleri* Busck but readily distinguished by its much darker color. It differs also in characters of male genitalia. In *milleri* the caudo-lateral projections of the tegumen are greatly reduced while in *moreonella* they are conspicuously developed. Otherwise these organs are much the same in both species."

Male genitalia (Fig. 37, of type).—Uncus roof-like, bilobed apically. Gnathos with three hook-like processes, the median one much the longest. Caudo-lateral processes of the tegumen asymmetrical, the left one much larger, its apex with a laterally extended appendage. Claspers asymmetrical, tubular, arcuate, the right one much larger than the left, and with a much recurved apex. Sicae slightly asymmetrical, obliquely angled near their middle.

Type.—In the United States Museum.

Type locality.—Cheyenne Mountain, Colo.

Distribution.—Known only from the above locality.

Food plant.—*Pinus ponderosa* Laws var. *scopulorum* Engelm.

Behaviour.—Unknown.

Remarks.—This species is known only from the unique type specimen. The central, longitudinal, white streak in the forewing, and the shape of the tegumental extensions, characterize this species.

9. *Evagora flaræ*, new species

Fig. 5

Antenna alternately marked with ochreous and black bands. Second joint of palpus with black-tipped scales below, white above, with a slight apical tuft; terminal joint white, with a black base. Face and vertex shining ivory white, the vertex with black scales laterally. Thorax dark grey. Forewing brownish-black with an admixture of white scales; a faintly indicated, shining, black patch on the disc at the basal one-fifth, beyond this a faint indication of a transverse, white fascia; an elongate, shining ante-medial, black spot on the fold, and a similar postmedial one near the trailing margin; beyond this, at the outer two-thirds, a poorly defined, outwardly angled, transverse fascia; subapical portion of wing with a few white scales extending obliquely for a short distance along the trailing edge; fringe light grey. Hind wing shiny silvery-grey; fringe shining greyish-white. Male with a long, ochreous hair-tuft extending from beneath the base of the hind wing. Fore- and mid-legs and tarsi, black, banded with white. Hind leg creamy-white; tarsus with black bands. Wingspread: 12.5-13 mm. Moth in the latter part of July.

Male genitalia (Figs. 38-40).—Uncus roof-like; shallowly bilobed apically. Gnathos with three hook-like processes, the median one much the longest. Caudo-lateral projections of tegumen asymmetrical, flap-like, the left one strongly elbowed apically. Claspers asymmetrical, tubular, twisted; the right clasper much larger than the left. Vinculum produced apically into two somewhat asymmetrical angled, digitate sicae. Ontario specimens, reared by officers of the Forest Insect Survey, have dimorphic male genitalia (Figs. 39, 40). In one form (Fig. 39), the tegumen is broader and shorter and the gnathos hooks are fused to the uncus as in one of the dimorphic forms of *E. starki* Free. (Fig. 30). These specimens are tentatively referred to *flaræ*.

Holotype.—Male, Cypress Hills Provincial Park, Saskatchewan, July 23, 1958 (Freeman and Lewis). Reared from *Pinus contorta* Dougl. var. *latifolia* Engelm. No. 6845 in the Canadian National Collection, Ottawa. *Paratype*.—Female, East Glacier, Montana, July 16, 1958 (Freeman and Lewis). Reared from *Pinus contorta* Dougl. var. *latifolia* Engelm.

Distribution.—Adults were reared only from Cypress Hills, Sask., and East Glacier, Mont. However, mines presumably of this species were collected in Kananaskis Park, north of Coleman, Alta. Some specimens reared from red-pine flowers by officers of the Forest Insect Survey in Ontario are tentatively considered to be this species.

Food plant.—*Pinus contorta* Dougl. var. *latifolia* Engelm., lodgepole pine, and *Pinus resinosa* Ait., red pine.

Behaviour (Fig. 61).—The late-instar larvae enter the needle near the base and mine to the apex. The frass is ejected from the entrance hole and accumulates among some webbing at the base of the needle. Some webbing is formed from the entrance hole to adjacent needles, and the larva uses this shelter to enter another needle, again near the base. The larva again mines to the tip and ejects frass as before. The larva now leaves the needle and bores into the staminate flowers near the base of one and

pupates. As far as is known, the mined needles are always adjacent to a staminate flower cluster. These observations were made from the type material.

Remarks.—Apparently an uncommon species. It is readily recognized by the larval behaviour. The shape of the lateral projections of the tegumen of the male genitalia closely resembles that in *moreonella* Heinr. *Florae* is a large, uniformly grey species, with a subapical narrow, recurved, transverse fascia. The mining habits of the Ontario specimens are not known.

10. *Evagora condignella* Busek, new combination

Fig. 11

Recurvaria condignella Bsk., 1929, Proc. Ent. Soc. Wash. 31: 13.

The type of this species is somewhat faded. I therefore quote the original description:

"Second joint of labial palpi black, slightly sprinkled with white scales on the inner sides and with apex narrowly pure white; terminal joint white with extreme base and two annulations, one on the middle and one just before apex, black; extreme tip white. Face white, bordered with black scales. Head and thorax white, mottled with black scales. Antennae yellowish with narrow black annulations. Forewings white, thickly mottled with black; a conspicuous deep black longitudinal streak from base of costa through the middle of the wing nearly to apex, partly edged with white scales; a thin, faint arrow-shaped transverse white fascia, pointing toward apex at apical fourth; a short black dash on the middle of the wing between the costal edge and the central longitudinal black streak; three groups of raised scales, predominately black, on dorsal part of the wing below the central black streak; cilia dark fuscous. Hindwings light fuscous, in the male with a long ochreous yellow tuft of dilated hairs on base of dorsum. Palpi and venation typical of the genus. Abdomen dark fuscous, in the male with three first joints light velvety yellow above. Legs black with narrow white tarsal annulations and with tuft on posterior tibiae conspicuously white.

"Alar expanse: 13-15 mm.

"Habitat: Prescott, Arizona; Valparaiso, Florida.

"Foodplant: Yellow Pine.

"U.S.N.M. Type No. 41690.

"Reared from yellow pine in Florida by Mr. E. W. Gemmer of the Forest Service, and at Prescott, Arizona, by Mr. L. G. Baumhofer of the U.S. Bureau of Entomology, the larvae "infesting new growth on Western yellow pine of sapling size, the small yellow larvae were abundant in the tips in certain localities. Work similar to the tip moth. Moths issued July 3-11, 1928." (Baumhofer).'

"By far the most conspicuously marked of our described American species of the genus, nearest in pattern to the oak-feeding *R. quercivorella* Chambers but bolder in design and color. From the two other North American pine feeders of the genus, *R. pinella* Busck and *R. moreonella* Heinrich, the present species is at once separated by the predominating black central streak on the forewing.

"The genitalia of all the American species of the genus (except the genotype, the introduced European *R. nanella* Hubner) are remarkably alike, conforming to a very distinct generic type, though easily separated specifically by small but constant differences in details; they all exhibit the same bilobed hooded uncus, the triple hooked gnathos, the asymmetrical winged tegumen, the slender asymmetrical harpes, of which one is commonly three to four times as large as the other, and the projecting curved hooks (sicae) from the vinculum. The two European species differ somewhat from this type, especially in having symmetrical harpes, and, as before suggested, it may eventually be sounder to restrict the generic name to these, and to revive one of the American names which have been made synonyms of *Recurvaria* for the American species, but this may well be postponed until a revision of the family is undertaken.

"The somewhat surprising occurrence of *R. condignella* in two so widely separated regions may be accounted for by the reforestation projects in Florida, where the species presumably has been introduced with nursery-stock from the West."

Male genitalia (Fig. 41, of paratype).—Uncus roof-like, shallowly bilobed apically. Gnathos with three hook-like processes, the median one much the longest. Caudolateral projections of the tegumen asymmetrical, the left one very much developed, broad throughout and with a narrow lateral appendage at the apex. Claspers asymmetrical, tubular, the right one much the larger, and arcuate. Sicae long, sinuous.

Type.—In the United States National Museum.

Type locality.—Prescott, Ariz.

Distribution.—Arizona and Florida.

Food plants.—*Pinus ponderosa* Laws, ponderosa pine.

Behaviour.—The late-instar larva bores into the tip of the twig. It is probably a needle-miner in the early instars.

Remarks.—The black, central, longitudinal streak of the forewing distinguishes this species from the other known pine species. It is known only from the type material.

11. *Evagora coniferella* Kearfott, new combination

Fig. 10

Recurvaria coniferella Kft., 1907, Can. Ent. 39: 3.

Forbes, 1923, Cornell Univ. Agr. Exp. Sta. Mem. 68: 300.

The type specimens of this species are too poor to redescribe. I therefore quote the original description:

"Head opalescent-white, palpi pale cinereous, third joint ringed with black at base and tip. Antennae whitish, annulated with brown. Abdomen and legs pale cinereous, the latter heavily ringed with black.

"Forewing yellowish-white or pale cinereous, overlaid with white in the middle of the wing from base to end of cell, and above the fold. There are the usual three oblique fasciae, all much broken into spots. The inner consists of a black dot on costa at base, and tuft of black and white raised scales below the fold at inner fifth. The second consists of a black dot on costa before the middle, hardly separated from a larger dot below it on the middle of the wing; below this is a third distinctly separated dot above the dorsum. The outer fascia begins in outer third of costa, with a large dot; below it, towards base, is a small round dot, and another towards apex in the form of a short horizontal line; below the first of these, above the dorsum, is another small dot. All of these dots, except on the costa, consist of tufts of black raised scales, bounded outwardly with white raised scales. The apex of wing is heavily powdered with black, obscurely forming four black marginal dots. Cilia gray, overlaid with black.

"Hind wing pale gray, cilia yellowish-gray. Expanse 9 mm.

"Two specimens, bred from larvae on pine, Ottawa, Canada, by Mr. Arthur Gibson. Issued June 20, 1905. Type in my collection. Cotype in Dr. Fletcher's collection.

"In general appearance this species most nearly resembles *R. apictripunctella* Clem., the larvae of which are common on hemlock. *Coniferella* is smaller, the arrangement of spots different, and is a very much darker species."

Male genitalia (Fig. 42, of paratype).—Uncus sub-conical, with long, lateral, anteriorly directed, coarse hairs; gnathos with three pendulous, hook-like processes, the median one slightly the longest and more acutely hooked at the apex; tegumen broad, truncate apically, and without lateral lobes; claspers, long, tubular, and twisted, the left one much aborted; aedeagus broadly arcuate; vinculum produced apically into two tapering sicae, and strongly protruding on the right side.

The genitalia of *coniferella* are remarkably different from those of the rest of the pine-feeding species in this genus. They are, however, much like those of the species that feed on spruce, balsam, eastern white cedar and juniper.

Type.—A female in the United States National Museum. The single male paratype is in the Canadian National Collection, Ottawa.

Type locality.—Ottawa, Ontario.

Distribution.—Known only from Ottawa and Sault Ste. Marie, Ont.

Food plant.—*Pinus banksiana* Lamb., jack pine.

Behaviour.—According to Mr. O. H. Lindquist, Sault Ste. Marie laboratory, Forest Biology Division, the larva mines the needles and bores into the staminate flowers.

Remarks.—This species has been collected only by Mr. Lindquist since the original type specimens were reared by Drs. Fletcher and Gibson in 1905. I have figured a specimen that agrees with the original description and was taken at the same time at Ottawa by Mr. C. H. Young, who collected in company with Fletcher and Gibson.

12. *Evagora canusella* Freeman, new combination

Fig. 6

Recurvaria canusella Freeman, 1957, Pan-Pac. Ent. 33: 12.

Antenna alternately marked with ochreous-white and black bands. Palpus long and upcurved in the female. Second joint of palpus whitish basally, blackish fuscous apically; the male with a strong, white triangular tuft on the inner side. Face and vertex shiny white, with a few fuscous scales laterally and dorsally. Thorax and forewing dark brownish grey, the latter with an obscure, black, raised spot below the fold at the basal one-third, the spot marked outwardly with a small white dash; a similar spot below the fold near the middle; and another above the fold at the outer two-thirds, bordered by white scales; apical portion of wing speckled with white scales, and small black dots or lunules; a faint white patch on the costa at the middle and one at the outer two-thirds. Hind wing shiny grey. Fringes of all wings shiny, light, ochreous grey. Under surface of forewing shiny ochreous grey; of hind wing light, shiny grey. Male with a long, ochreous hair-pencil arising from beneath the anal angle of the hind wing. Tibiae and tarsi banded with dark-brown and white scales. Wing spread: 10-11 mm. Moth in mid or late June.

Male genitalia (Fig. 43, of paratype).—Uncus trifid at apex. Gnathos with a single, long hook. Caudo-lateral projection of tegumen strongly produced on the left side. Claspers asymmetrical, tubular, twisted; the right one considerably the larger, and expanded at the base. Aedeagus arcuate. Vinculum produced apically into two almost symmetrical, elbowed sicae.

Type.—In the Canadian National Collection, Ottawa.

Type locality.—Squillax (near Salmon Arm), British Columbia.

Distribution.—Known only from the type locality.

Food plant.—*Pinus contorta* Dougl. var. *latifolia* Engelm., lodgepole pine.

Behaviour (Fig. 62).—The larva enters the needle at the base, near the apex of the sheath, and mines upward to the tip, ejecting the frass through the entrance. It then constructs a silk tube to an adjacent needle and mines upward. A second elongate hole may be cut near the middle of this mine, and a silk tube constructed to a third needle if required to complete the growth. No frass is left in the mined needles or in the silk tubes. Pupation occurs in September in a white cocoon outside the mine. (On the twig in the rearing jars). These observations were made from topotypical material.

Remarks.—This species has been confused with *E. milleri* Bsk. However, it is readily distinguished by the male genitalia, the mining habits, and time of pupation. It is a pest of lodgepole pine in the vicinity of Squilax, B.C.

EUCORDYLEA Dietz

Eucordylea Dietz, 1900, Ent. News 11: 349.

Forbes, 1923, Cornell Univ. Agr. Exp. Sta. Mem. 68: 302.

Meyrick, 1925, in Wytsman, Gen. Insect. Fasc. 184: 59.

This genus was proposed by Dietz for a single male specimen from Hazleton, Penn., that he named *Eucordylea atrupictella*, the food plant of which is unknown. The genus was based mainly on the much-expanded scale tuft on the upper side of second joint of the male palpus (Fig. 28). In this paper, no species of *Eucordylea* are described. However, a few specimens have been reared by various officers of the Forest Biology Division from spruce, balsam fir, Douglas fir, eastern white pine (Fig. 12), lodgepole pine and ponderosa pine. These specimens are closely allied to *atrupictella* morphologically, but because of the lack of specimens and knowledge of the mining habits, it is premature to assign specific names to them at the present time. However, a description of adult characters is presented to assist in the recognition of the genus.

The forewing (Fig. 12) is often ochreous or ochreous-grey, with a blackish, oblique, basal fascia, and a postmedial, blackish, costal patch or fascia. As previously mentioned, the males of this genus have an expanded scale-tuft on the palpus, and, in common with those of the genus *Evagora* Clem., have an ochreous hair-pencil that arises from near the base of the underside of the hind wing.

The male genitalia, as illustrated from those of the type of *atrupictella*, are like those of *Evagora*, asymmetrical, and possess lateral, tegumental lobes. The gnathos has a single, well-developed hook. The uncus, unlike that of *Evagora*, is columnar with lateral bristles.

In Canada, this genus is represented from the west coast to the east.

EXOTELEIA Wallengren

Exoteleia Wallengren, 1881, Ent. Tidskr. 2: 94.

Meyrick, 1925, in Wytsman, Gen. Insect. Fasc. 184: 59.

Paralechia Busck, 1903, Proc. U.S. Nat. Mus. 25: 820.

13. *Exoteleia pinifoliella* Chambers

Fig. 13

Gelechia pinifoliella Chamb., 1880, Journ. Cin. Soc. Nat. Hist. 2: 181.

Comstock, 1890, Fifth Rept. U.S. Ent. Comm., p. 793.

Paralechia pinifoliella Chamb., Busck, 1903, Proc. U.S. Nat. Mus. 25: 820.

Swain, 1913, 43rd. Ann. Rept. Ent. Soc. Ontario, p. 90.

Forbes, 1923, Cornell Univ. Agr. Exp. Sta., Mem. 68: 290.

Exoteleia pinifoliella Chamb., Meyrick, 1925, in Wytsman, Gen. Insect. Fasc. 184: 60.

Bennett, 1954, Can. Ent. 86: 49.

Bennett, 1954, Proc. Ent. Soc. Wash. 56: 41.

Bennett, 1954, Can. Ent. 86: 310.

Antenna white or dirty white, with dark-brown or black bands. Palpus white; second joint with brown scales outwardly; terminal joint with a submedian and a subapical brown ring. Head and thorax white, mottled with light brown specks. Forewing light golden brown with three transverse, white fasciae; the first fascia at the basal one-quarter, the second, just beyond the middle, broader, and flecked with golden brown scales, the third at the outer four-fifths, narrow; wing from basal fascia to base white with brown scales, and, at inside of this fascia, near the trailing margin, a small patch of brown, raised scales; a similar patch of scales on each side of the post-

median white fascia; apex of wing white, sprinkled with brown scales; outer costal margin and apical fringe light brown; fringe of trailing margin, pale fawn. Hind wing greyish-white, with pale-fawn fringe. Legs purplish-brown, banded with white; hind femora creamy-white above. Wingspread: 9-10 mm. Moth in June.

Male genitalia (Fig. 45).—Uncus subconical, with lateral margin strongly arcuate near base; gnathos a central hook-like process with two lateral lobes; clasper narrow, with bulbous base and tapered apex; vinculum complex, with two lateral, membranous, digitate, basal processes, and produced anteriorly into a pair of curved sicae, and a pair of sub-triangular plates with knobbed, posterior apices; aedeagus short, thick, tubular. The male genitalia resemble those of *dodecella*, but the clasper of *pinifoliella* is shorter, and the lateral margin of the uncus is more arcuate near the base.

Type.—In the United States National Museum.

Type locality.—Ithaca, New York.

Distribution.—The pine areas of eastern North America, south to Georgia.

Food plants.—Several species of thick-needled pines, particularly *Pinus banksiana* Lamb., jack pine, in Ontario.

Behaviour (Fig. 63).—Three or more needles are mined by the larva during its life. The young larva enters a needle in July, near the tip, and mines to the apex, leaving some frass in the mine, where it overwinters (Fig. 63a). In the spring, later-instar larva enter another needle closer to the base, and mine to the apex of the needle, ejecting the frass through the entrance hole. As it continues feeding from the apex of the needle back to the entrance hole, the larva leaves some frass in the apical portion of the mine (Fig. 63b). When the larva is full grown, it lines the mine with silk and constructs a silk membrane over the entrance hole. Pupation takes place in the mine in May. These observations were made in the Ottawa, Ont., district. There is one generation a year in the northern part of the range, and two or more in the southern part.

Remarks.—This is a common species, often injurious. It is smaller than *dodecella* and without magnification appears golden brown, with white fascia. *Dodecella* appears grey, with dark, transverse fasciae. A third undescribed species (Fig. 14), resembling *pinifoliella*, mines the needles of mugho pine in the Ottawa region. It is somewhat larger and darker than *pinifoliella*, and has dark brown hind wings. The immature stages of this form are not sufficiently well known to permit it to be described at present.

14. *Exoteleia dodecella* Linnaeus

Figs. 15, 25

Tinea dodecella Linn., 1758, Syst. Nat. p. 539.

Exoteleia dodecella Linn., Wallengren, 1881, Ent. Tidsch. 2: 94.

Sheppard, 1930, Ann. Rept. Ent. Soc. Ont. 61: 79.

Martin, 1959, Can. Ent. 91: 5.

Hering, 1957, Bestimmungstabellen der Blattminen von Europa, 2: 780.

Antenna alternately marked with light and dark brown bands. Second joint of palpus white above, dark brown beneath; terminal joint white with two black bands. Face white. Vertex shining, mottled with brown and grey. Abdomen brown, with white scales covering the male genitalia. Forewing dirty white or light grey with somewhat indistinct, dark-brown, basal patch, submedian and postmedian transverse faciae, and apical patch. At base of wing a median, black spot, and on the discal region of the wing three pairs of small, black, raised, scale patches; outer margin of wing with three small dark-brown spots at base of fringe; apical portion of fringe brown, barred with white; rest of fringe light grey-brown, barred with white apically and dark brown basally. Hind wing grey; fringe light grey. Hind leg cream-white with black- and white-banded tarsi. Fore- and mid-legs blackish; tarsi white-banded. Wingspread: 12-15 mm. Moth in the first half of June.

Male genitalia (Fig. 46).—Uncus subconical; gnathos with a central, hook-like process, and two lateral, curved ones; clasper long, pointed, with bulbous base; vinculum complex, with two lateral, membranous, digitate, basal processes, and produced anteriorly into a pair of hook-like sicae, and a pair of processes with knobbed apices; aedeagus short, thick, tubular.

Type.—?

Type locality.—Europe.

Distribution.—A European species, known in North America only from Southern Ontario.

Food plants.—*Pinus sylvestris* L., Scots pine; and *Pinus mugho* Turra., Mugho pine.

Behaviour (Fig. 64).—The first-instar larva enters a needle near the tip in early July. It covers the entrance with silk, mines toward the apex and moults, leaving the frass in the mine. In late summer, the larva enters another needle near the apex and mines to the tip. Most of the frass is ejected from this mine, and before cold weather the larva seals the entrance hole with silk, moults, and hibernates for the winter (Fig. 64a). In early spring, the larva leaves this mine in which it overwintered, usually without feeding in it, and enters another needle near the tip. At this stage about one-half to one-third of the apical portion of the needle is mined (Fig. 64b). The entrance is again sealed, and the larva moults. After moulting, feeding is often resumed in the mine, and a new exit-hole is often made basal to the sealed entrance hole. The larva now leaves the mine, and bores into the developing bud near the base. The larva moults in the bud and when mature, it pupates in the bud. This bud soon withers and dies (Fig. 64c).

Remarks.—Hering (1957) states that in Europe the last mine always has two openings, the apical one of which is sealed with silk. Our observations, made in the Ottawa district, show that the larva sometimes does not make another hole in the mine. Perhaps this slight difference in behaviour is caused by the environment.

CHIONODES Hübner

Chionodes Hübner, (1825) Verz. bekannt. Schmett. p. 420.

Meyrick, 1925, in Wytzman Gen. Insect. Fasc. 184: 59.

Busck, 1939, Proc. U.S. Nat. Mus. 86: 574.

15. *Chionodes retiniella* Barnes and Busck

Fig. 16

Gelechia retiniella B. & Bsk., 1920, Contr. Nat. Hist. Lep. 4: 228.

Gelechia langei Keifer, 1936, Bull. So. Cal. Acad. Sci. 35: 20.

Chionodes retiniella B. & Bsk., Busck, 1939, Proc. U.S. Nat. Mus. 86: 574.

Chionodes langei Keif., Busck, 1939, Proc. U.S. Nat. Mus. 86: 547 (as synonym of *retiniella* B. & Bsk.).

Antenna alternately marked with black and white bands. Palpus white with a few yellowish or fuscous scales at base. Head shining bone-white. Thorax and extreme base of costa of forewing light fawn. Forewing golden yellow with raised scales in the basal half, and with white markings as follows: a white basal band extending from near the costa to the posterior margin; a white spot near the costa at the basal one-quarter; one in the fold at about one-third; one at the costal half; a transverse, white fascia at three-fourths, extending somewhat obliquely inward; apex with a few white scales at base of fringe; fringe whitish. Hind wing shining fuscous; fringe whitish yellow. Femur and tibia brown with white patches; tarsi dark brown with white rings. Undersurface of forewing shining fuscous, with a whitish subapical band. Undersurface of hind wing shining fuscous. Wingspread: 15-15.5 mm. in the British Columbia and Washington specimens; 18-21 mm. in the original description of *retiniella*; 20 mm.

in the original description of *langei*. Moth in mid-May in California; late June and early July in southern British Columbia.

Male genitalia (Fig. 47).—Uncus broad, spoon-shaped; gnathos a stout hook-like process; clasper divided, the upper process hooked inwardly near apex, the lower process digitate, membranous; aedeagus elongate, with long, basal stalk and with strongly developed apical projections.

Type.—In the United States National Museum, Washington, D.C. (The type of *langei* Keif. is also there).

Type locality.—Verdi, Nevada (*retiniella*); Placerville, California (*langei*).

Distribution.—California, Nevada, Washington, and southern British Columbia.

Food plant.—*Pinus ponderosa* Laws, ponderosa pine.

Behaviour (Figs. 65).—The larva at first mines the apical portions of several needles, ejecting the frass through the entrance hole (Fig. 65a). Later, the larva ties the needles into a bundle using the previously mined and adjacent needles, or migrating to a new site to make the bundle. Within the bundle, the entrance holes are much elongated (Fig. 65b) and some frass adheres to the silk ties. At maturity the larva migrates to a new site and makes a new bundle within which it pupates without feeding (Fig. 65c). This habit is similar to that of the species of *Ocnerostoma*. It is interesting to note that the last bundle is often made, with slight alterations, from one previously constructed apparently by aphids (Fig. 65c). Pupation occurs in southern British Columbia in June.

Remarks.—The above description of the adult and mining habits were made from material gathered by the writer and Mr. G. G. Lewis in southern British Columbia. The maculation and wingspread of the moth do not quite coincide with those given in the original descriptions of *retiniella* or of *langei*. Nothing is known of the mining habits of these in the type localities. It is possible that more than one species is involved. Until more is known about these insects from California and Nevada, I consider all of them *retiniella*.

YPONOMEUTIDAE

ZELLERIA Stainton

Zelleria Stainton, 1849, Cat. Brit. Tin. Pteroph. p. 22.

Forbes, 1923, Cornell Univ. Agr. Expt. Sta. Mem. 68: 348.

16. *Zelleria haimbachi* Busck

Fig. 17

Zelleria haimbachi Bsk., 1915, Proc. Ent. Soc. Wash. 17: 91.

Forbes, 1923, Cornell Univ. Agr. Expt. Sta. Mem. 68: 348.

Antenna white, annulated with light brown. Palpus white. Head white. Thorax white, with tegulae and sides light yellowish brown. Forewing golden brown, with a median, white, longitudinal streak from the base of costa almost to the apex; apical region with a few dark-tipped scales; undersurface pale fawn. Hind wing pale fuscous above; shiny white beneath. Fringes of all wings shining white. Abdomen white. Legs white. Wingspread: 14-15 mm. Moth in early July.

Male genitalia (Fig. 48).—Uncus bifid, the arms parallel. Gnathos atrophied. Profile of tegumen and vinculum subrectangular, the vinculum produced into a much extended saccus. Clasper elongated, arcuate near apex. Aedeagus long, tubular. Eighth sternite developed into a pair of flap-like structures. Coremata present but much reduced.

Type.—In the United States National Museum, Washington, D.C.

Type locality.—Wenonah, New Jersey.

Distribution.—New Jersey, western Quebec, Ontario, southern British Columbia.

Food plants.—*Pinus banksiana* Lamb., *P. ponderosa* Laws and *P. contorta* Dougl. var. *latifolia* Engelm.

Behaviour (Fig. 66).—The larva mines the terminal needles at the base near a staminate flower cluster, and only within the needle sheath, eventually all of these portions of the needles are devoured (Fig. 66a). The needles are held in the sheath by some silk strands, but are easily removed and soon fall away. Several bundles of needles are utilized by the larva. The frass is ejected from the needle sheath and usually accumulates at the base of adjoining sheaths. Pupation occurs in late June in an elongate white cocoon (Fig. 66b) between the bases of the mined sheaths. The above observations were made in Ontario.

Remarks.—Specimens from coastal British Columbia and from southern Washington are much lighter than eastern ones or those from the interior of British Columbia. The former may be more closely allied to *Zelleria arizonica* Braun, described from specimens taken at Flagstaff, Arizona, in August. The early stages and habits of this species are unknown.

OCNEROSTOMA Zeller

Ocnerostoma Zeller, 1847, Linn. Ent. 2: 298.

17. *Ocnerostoma strobivorum*, new species

Fig. 22

Head antenna, thorax and abdomen, white. Forewing white, slightly yellowish near apex; fringe white. Hind wing and fringe white. Undersurface of forewing white; in certain light-reflections slightly fuscous, with white margins; of hind wing, white. Legs white, with apical tarsal joints slightly fuscous. Wingspread: 8-9 mm. Moth in the latter half of June.

Male genitalia (Fig. 51).—Uncus bifid, lyrate. Gnathos atrophied. Profile of tegumen and vinculum obovate; lateral walls of tegumen connected by a ventral, arcuate bridge; vinculum produced basally into an extended saccus. Clasper broadly arcuate, the dorsal margin recurved. Aedeagus very long, tubular. Eighth venter with a pair of well-developed coremata containing long hair-pencils.

Holotype.—Male, Constance Bay, Ontario, June 21, 1954 (T.N. Freeman). Reared from *Pinus strobus* Linn. No. 6846 in the Canadian National Collection, Ottawa.

Paratypes.—Five males, Constance Bay, Ontario, June 19-22, 1954 (T.N. Freeman). Reared from *Pinus strobus* Linn. One male, Bell's Corner, Ontario, June 27, 1955 (T.N. Freeman). Reared from *Pinus strobus* Linn. Three males, three females, South March, Ontario, June 25, 1941 (G. A. Hobbs).

Distribution.—Known to the writer only from eastern Ontario, although probably more widely distributed.

Food plant.—*Pinus strobus* Linn., eastern white pine.

Behaviour (Fig. 70).—The larva mines from near the tip of the needle toward the base, mining the apical portion in late summer, and overwintering in the needle. Feeding is resumed in the spring in the same needle. The needle is mined almost to the base. The frass is left in the mine and extends from the apex to within the larval length of the exit hole. The frass in the mine makes the mined needle appear greyish. The larva leaves the mined needle and without further feeding, ties from five to 10 needles together in a bundle. Pupation occurs within this bundle in a thin silk lining.

Remarks.—It is not improbable that this species has been recorded as the introduced European species *O. piniariellum* Zell. A much larger form occurs on *Pinus resinosa* Ait. in Ontario, the mining habits of which are similar to those of *strobivorum*, but whose mine is brownish. I am unable to assign a specific name to it until more information is available.

18. *Ocnerostoma piniariellum* Zeller

Figs. 21, 27

Ocnerostoma piniariella Zell., 1847, Linn. Ent. 2: 299.

Felt, 1922, Jour. Econ. Ent. 15: 432.

Forbes, 1924, Jour. N. Y. Ent. Soc. 32: 173.

Hering, 1957, Bestimmungstabellen der Blattminen von Europa, 2: 780.

Harris, 1958, Can. Ent. 90: 627.

Head, antenna, thorax and abdomen white. Forewing white, sometimes slightly yellow near apex and along trailing margin; fringe shining white. Hind wing shining white; fringe white. Undersurfaces of wings white. Legs white outwardly, dark fuscous or black inwardly. Wingspread: 11-13 mm. Moth in late June.

Male genitalia (Fig. 52).—Uncus bifid, lyrate, slightly shorter than in *strobivorum*. Gnathos atrophied. Profile of tegumen and vinculum subrectangular; lateral walls of tegumen connected by a ventral, arcuate bridge; vinculum produced into an extended saccus. Clasper somewhat arcuate, narrower than in *strobivorum*. Aedeagus long, tubular. Coremata present.

Type.—Probably in Berlin, Germany.

Type locality.—Germany.

Distribution.—Southern British Columbia; northern Montana; Europe.

Food-plants.—*Pinus contorta* Dougl. var. *latifolia* Engelm., and *P. monticola* Dougl.; *P. sylvestris* L. in Europe.

Behaviour (Fig. 71).—The larva mines from the apex of the needle toward the base, the mine occupying approximately three-fourths of the needle. The mine is commenced in late summer, the larva overwintering in the mine, and continues feeding in the spring. Frass is left in the mine and extends from the apex to within the larval length of the exit hole that is made when the larva is mature (Fig. 71a). The frass in the mine makes the mined needle appear purple. At this time the larva leaves the mine and ties several needles into a bundle in which it pupates among several silk strands (Fig. 71b).

Remarks.—I have not seen authentic material of *piniariella* from eastern North America. It is possible that some, if not all, eastern records refer to *strobivorum*.

ARGYRESTHIA Hübner

Argyresthia Hübner, (1825), Verz. bekannt. Schmett. p. 422.

Busck, 1907, Proc. U.S. Nat. Mus. 32: 5.

Forbes, 1923, Cornell Univ. Agr. Expt. Sta. Mem. 68: 344.

19. *Argyresthia flexilis*, new species

Fig. 18

Antenna white, banded with fuscous, and with some brown scaling at base. Palpus white inwardly, yellowish outwardly, and slightly fuscous at apex. Head white. Thorax yellowish-white in male; white in female. Forewing of male white, with a yellowish cast, particularly at base and on disc; of female white. Hind wing smoky. Fringes of all wings shining white. Undersurfaces of all wings fuscous, with white fringes. Hind leg white; terminal tarsi with fuscous bands. Fore and mid-tibiae and tarsi, fuscous. Wingspread: 11 mm. Moth in late June.

Male genitalia (Fig. 49).—Uncus conical; cleft. Gnathos paired, pendulous, covered with specialized scales. Tegumen broad, membranous. Vinculum a subrectangular band, with lateral, anterior projections. Clasper broad, membranous, flap-like. Aedeagus very long, tubular. Eighth venter with a pair of well-developed coremata, containing long hair pencils, and a triradiate, sclerotized structure.

Holotype.—Male, St. Marys, Montana, June 17, 1958 (Freeman and Lewis). Reared from *Pinus flexilis* James. No. 6866 in the Canadian National Collection, Ottawa.

Paratype.—Female, Babb, Montana, June 26, 1958 (Freeman and Lewis). Reared from *P. flexilis*.

Distribution.—Known only from the above localities.

Food plant.—*Pinus flexilis* James, limber pine.

Behaviour (Fig. 67).—The late instar larva ties the needles into a bundle and mines two or more of them, starting below the middle of the needle, and mining toward the apex for a distance of approximately the central third (Fig. 67a). Frass is ejected through the mine entrance. At maturity, the larva constructs a new bundle, within which it pupates in a dense, white cocoon (Fig. 67b).

Remarks.—Apparently an uncommon species, restricted in its distribution to the narrow range of the food plant, limber pine.

20. *Argyresthia pilatella* Braun

Fig. 19

Argyresthia pilatella Brn., 1910, Ent. News 21: 171.

Keifer, 1930, Pan. Pac. Ent. 7: 76.

The original description by Dr. Braun follows:

"Face and head gray, front part of the tuft whitish; basal joint of antennae almost pure white, remainder annulate with black. Thorax dark gray. Forewings with the whitish somewhat shining ground color almost overlaid with brownish gray scales, arranged for the most part along the costal and dorsal margins into narrow strigulae, between which the white ground color is evident. At the middle of the dorsal margin, these scales are collected into a broad and much darker patch, which extends obliquely backward as a curved streak nearly to the costal margin where it meets the apex of a similar but much smaller and less distinct costal streak, thus forming an outwardly angulated more or less distinct fascia. Sometimes the dark scales are almost evenly distributed over the entire surface of the wing except along the costa near the apex, where the strigulae are distinct. Along the apical half of the costa, the white interspaces between the strigulae are broader; sometimes the only dark streak is a conspicuous one just before the apex. A black apical dot, sometimes obsolete. Cilia opposite the strigulae and around the apex gray becoming paler toward the tornus. Hind wings silvery gray, their cilia tinged with brown. Abdomen and legs gray, tips of the tarsi darker. Expanse 9.5-10.5 mm.

"Nine specimens: Mills College, Cal., May 20, 1908; San Francisco, April 12, 1909; all collected by Mr. G. R. Pilate. A dark indistinctly marked species, apparently not closely related to any of the described American species. Veins 7 and 8 of the forewings are stalked.

"Type in my collection; paratypes in the California Academy of Sciences and in Mr. W. D. Kearfott's collection."

Male genitalia (Fig. 50, of paratype).—Much like those of *A. flexilis* but with shorter, blunter uncus; a shorter aedeagus with apical armature, and a V-shaped furcula.

Type.—In the collection of Dr. Annette Braun, Cincinnati, Ohio.

Type locality.—Mills College, California.

Distribution.—Known only from Mills College and San Francisco, Calif.

Food plant.—*Pinus radiata* Don., Monterey pine.

Behaviour.—According to Keifer (1930) the larva is reddish, and mines the needles from the base. The pupa is in a rough cocoon spun in contact with a needle or other substance.

Remarks.—I am grateful to Dr. C. D. MacNeil, California Academy of Sciences, San Francisco, Calif., who kindly loaned a paratype and reared specimens for study.

OLETHREUTIDAE

EPINOTIA Hübner

Epinotia Hübner, (1825) Verz. bekannt. Schmett. p. 377.

Heinrich, 1923, U.S. Nat. Mus. Bull. 123: 194.

Forbes, 1923, Cornell Univ. Agr. Expt. Sta. Mem. 68: 398.

21. *Epinotia aridos*, new species

Fig. 23

Antenna cream-white, banded with dark brown between the scale rings. Palpus cream-white with dark-brown scales outwardly on terminal joint. Femora and tibia cream-white; tarsi light ochreous, banded with black. Head and thorax cream-white. Forewing cream-white with fuscous markings and scattered golden scales on apical half; basal patch, occupying basal third, fuscous with a few whitish scales, the outer margin curving outward to the fold, then extending directly to the posterior margin; transverse postmedian fascia extending across wing obliquely from just beyond the costal half almost to the posterior margin, containing and lined outwardly with golden scales; beyond, a somewhat oblique transverse band of cream-white and golden scales; apical portion of wing fuscous with an admixture of cream-white and golden scales; extreme apex with a round fuscous spot containing a few central golden scales; outer half of costa with four whitish geminations; fringe white at base, fuscous outwardly. Hind wing fuscous; fringe whitish, with fuscous base. Wingspread: 6 mm. Moth in late June.

Male genitalia (Fig. 54).—Uncus bifurcate, each process digitate. Socius heavily chitinized, digitate. Aedeagus short, stout, straight; cornuti a cluster of long spines. Clasper broad, scimitar-shaped, hairy.

Holotype.—Male, East Glacier, Montana, June 25, 1958 (Freeman and Lewis). Reared from *Pinus contorta* Dougl. var. *latifolia* Engelm. No. 6847 in the Canadian National Collection, Ottawa. *Paratype*.—One male, June 23, 1958, same locality, food plant and number.

Food plant.—*Pinus contorta* Dougl. var. *latifolia* Engelm., lodgepole pine.

Behaviour (Fig. 68).—Late-instar mine without frass, occupying approximately the apical half of the needle; one large hole at the mine base with a silken ramp. Pupation in early June in the mine, the pupa working its way to the exit hole for the moth emergence.

Distribution.—Known only from East Glacier, Montana.

Remarks.—This species is closely allied to *Epinotia meritana* Heinr. The clasper of *aridos* is broad throughout, and the basal patch of the forewing is uniformly fuscous. The clasper of *meritana* is abruptly enlarged at the apex, and the inner half of the basal patch is white.

TORTRICIDAE

ARGYROTAENIA Stephens

Argyrotaenia Stephens, 1852, List Spec. Anim. Brit. Mus. 10: (Lep.) 67.

Forbes, 1923, Cornell Univ. Expt. Sta. Mem. 68: 490 (as a subgenus).

Freeman, 1944, Sci. Agr. 25: 81.

Freeman, 1958, Can. Ent. Suppl. 7: 44.

22. *Argyrotaenia tabulana* Freeman

Fig. 24

Argyrotaenia pinatubana, Burke, 1932, United States Dept. Agr. Cir. 224: 3.

Argyrotaenia tabulana Freeman, 1944, Sci. Agr. 25: 87.

Freeman, 1958, Can. Ent. Suppl. 7, p. 48.

Head, palpus, and thorax light brown. Forewing light brownish grey with a pinkish cast, and irrorated with dark reddish-brown lines; basal patch represented by two dark-reddish-brown, angulated lines; median band oblique, a bit darker than the ground colour, with purplish cast, and bordered outwardly and inwardly with irregular, reddish-brown, distinct lines; costal spot beyond the median band reddish-brown, with darker inner and outer edges, and contiguous or slightly remote from a similarly coloured elongate spot above the tornus; beyond the costal spot one or two short, dark-reddish-brown, preapical lines from the costa; fringe light reddish brown. Hind wing smoky, becoming lighter toward the base; fringe light and with dark basal line and becoming tawny toward the apex. Underside of forewing smoky with light ochreous costal and outer margins, and obliquely crossed with evenly spaced dark-fuscos lines. Underside of hind wings white, with several dark-fuscos spots at the apex. Wingspread: 13-17 mm. Moth from late April to early June.

This species exhibits a certain amount of variation of maculation. The ground colour varies from light brown to greyish, and the median band may be represented only by the darker outer borders, or it may be considerably darker than the ground colour, but with still darker distinct outer borders. The maculation of this species somewhat resembles that of *pinatubana* Kft.

Male genitalia (Fig. 53, of paratype).—Uncus long, digitate, slightly arcuate; gnathos with two sickle-shaped arms, fused at their apices; clasper broad, globose, heavily chitinized along ventral margin; transtilla a simple band, connecting the dorsal bases of the claspers; aedaeagus long, tubular, tapering toward apex, and with numerous, short, pointed, deciduous cornuti.

Type.—In the Canadian National Collection, Ottawa, Canada.

Type locality.—Constance Bay, Ont.

Food plant.—*Pinus banksiana* Lamb.; *Pinus contorta* Dougl. var. *latifolia* Engelm.; *Pinus albicaulis* Engelm.; *Pinus ponderosa* Laws.

Distribution.—Que., Ont., Man., B.C., Mont., Wyo., Wash.

Behaviour.—According to Burke (1932), the larva at first mines from the tip of a needle almost to the base. Later it ties two or more needles together into a bundle or tube, and lines the interior of the tube with silk. Feeding takes place within the bundle. As the larva matures, additional needles are added to the bundle or a new bundle is made from the current growth. In late summer or early fall the larva drops to the ground and pupates in a flimsy cocoon in the ground litter.

Remarks.—This species is not to be confused with the bundle-making species *Argyrotaenia pinatubana* Kft. (Fig. 68), which feeds on white pine. Both species are similarly coloured, but the reddish-brown bands of the forewing of *tabulana* are lined with dark borders, those of *pinatubana* are not.

23. *Argyrotaenia pinatubana* Kearfott

Fig. 20

Tortrix politana Packard, 1890, Fifth Report U.S. Ent. Comm. p. 791 (life history).

Eulia pinatubana Kearfott, 1905, Can. Ent. 37: 9.

Forbes, 1923, Cornell Univ. Agri. Exp. Stat., Mem. 58: 490.

Meyrick, 1913, Gen. Insect., Fasc. 149: 39.

Argyrotaenia pinatubana Kearfott, McDunnough, 1939, Chec List Lep. Can. and U.S.A., Pt. 2, p. 57.

Freeman, 1944, Sci. Agri. 25: 85.

Freeman, 1958, Can. Ent. Suppl. 7, p. 47.

Sexes similar. Head and thorax ochreous. Abdomen grey, blackish or mouse-coloured with ochreous apical tufting, more noticeable on the male. Forewing with broad, well-defined, orange to reddish-ochreous, basal patch, the outer margin of the patch distinct from costa to posterior margin; median band and outer costal spot well defined and concolorous with the basal patch, the median band usually with a lighter area near the middle of its inner margin; the bands separated by a complete fascia of whitish or light ochreous, this colour predominating in the apical region. Hind wing smoky, becoming paler basally; fringe paler with darker basal line. Expanse: male, 13-15 mm.; female, 14-18 mm. Moth from late April to early June.

Male genitalia.—Similar to those of *tabulana* Free.

Type.—In the American Museum of Natural History.

Type locality.—Essex Co. Park, N.J.

Distribution.—N.S., N.B., Que., Ont., Maine, N.J., N.Y., Mass., Fla.

Food Plant.—*Pinus strobus* L.

Behaviour (Fig. 69).—The larva ties several needles into a bundle and mines from near the base of a needle, to or almost to, the apex. Several needles are mined, and the frass is ejected from the mine. Additional holes are often cut nearer the apex (Fig. 69a). Sometimes these are adjacent in different needles, and, as the larva matures, the openings are much elongated, giving the needle a boat-like appearance, and are made on the inner needles or on the inner surface of an outer needle (Fig. 69b). The larva constructs several bundles. The last bundle does not normally contain mined needles. At this stage the larva lines the inside of the lower portion of the bundle with silk, and, as first observed by Mr. H. R. Foster, St. Williams, Ont. laboratory, Forest Biology Division, the larva severs a needle at the apex of the silk lining, and pulls the severed needle down into the base of the bundle, where it feeds on that needle within the protection of the bundle. The apex of the needle often protrudes beyond the cut off portion of the bundle (Fig. 69c) and the larva feeds from the base of the cut portion to the apex.

Remarks.—This species is easily recognized by the larval behaviour. It is frequently injurious to white pine in eastern North America and is commonly known as the pine-tube moth.

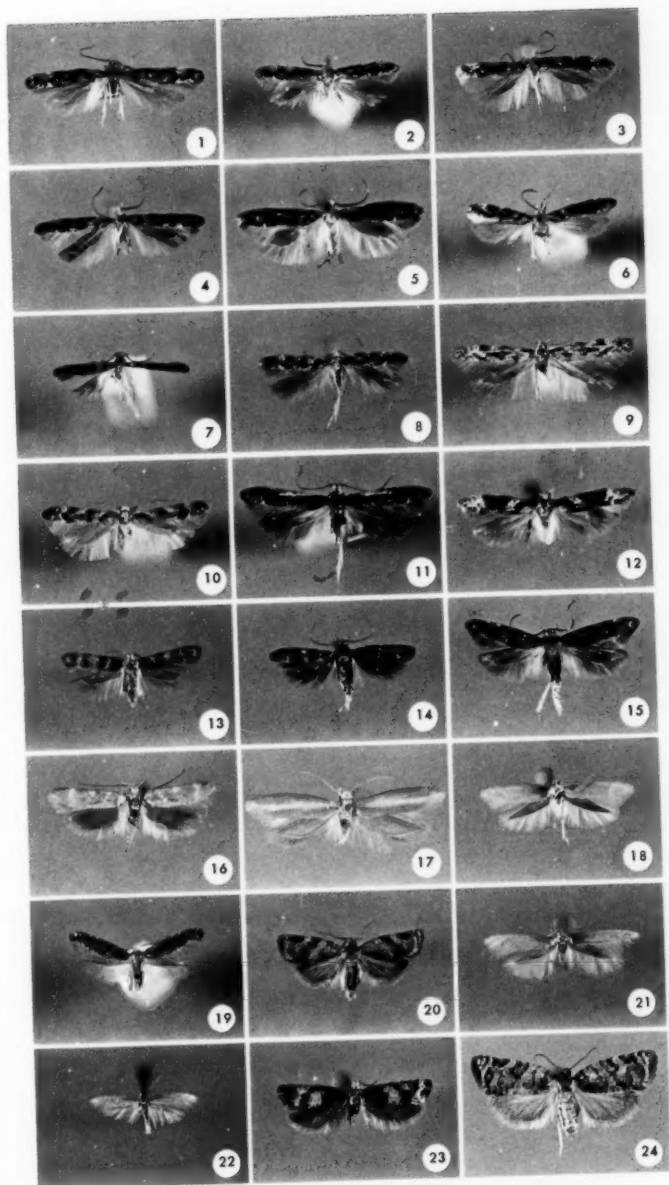
SUMMARY

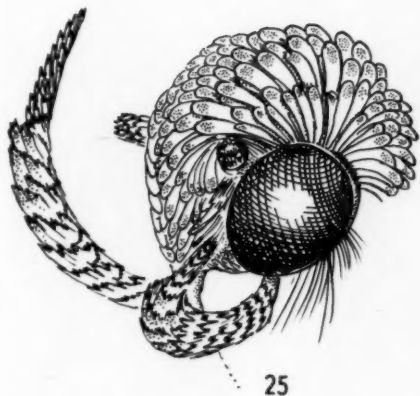
The introductory parts of this paper deal with some of the taxonomic aspects of lepidopterous needle-mining species on pine and other conifers. The taxonomic history of this group is briefly reviewed, and an account is given of the material studied and the methods used in the study. The main part comprises the taxonomy of 23 species of pine-needle miners contained in the families Gelechiidae, Yponomeutidae, Olethreutidae, and Tortricidae. The generic name *Recurvaria* Haw., which has been associated with some of the gelechiid species for many years, is not applicable, and these species are therefore placed in the genus *Evagora* Clemens. Five new species of *Evagora* are

described, and 10 other gelechiid species are dealt with. Five yponomeutid species including two new ones, one new species of olethreutid, and one tortricid species, are included.

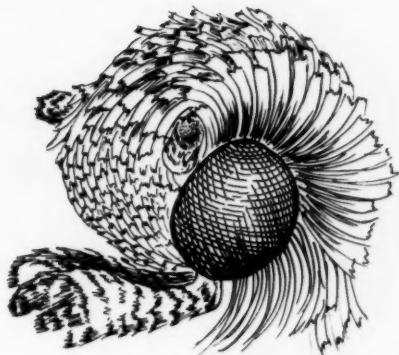
Three keys are provided to assist in the recognition of these insects; one to the various genera based on the male genitalia; one to the species based on adult characters; and one to most of the species based on the mining habits of the late-instar larvae. The mining habits of the larvae are considered as basic for the recognition of the various species. Morphological characters, when present, are utilized as supporting ones, but are given subordinate status. The moths, male genitalia, and the mines are illustrated.

1. *Evagora starki* Free., holotype, male, Mt. Eisenhower, Alta.
2. *Evagora resinosae* n. sp., holotype, male, North Bay, Ont.
3. *Evagora ardas* n. sp., holotype, male, East Glacier, Mont.
4. *Evagora biopes* n. sp., holotype, male, Cypress Hills, Sask.
5. *Evagora florum* n. sp., holotype, male, Cypress Hills, Sask.
6. *Evagora camusella* Free., holotype, male, Squilax, B.C.
7. *Evagora pinella* Bsk., paratype, male, Manitou, Colo.
8. *Evagora lewisi* n. sp., holotype, male, Cowley, Alta.
9. *Evagora milleri* Bsk., paratype, male, Yosemite National Park, Calif.
10. *Evagora confisella* Kft., male, Ottawa, Ont.
11. *Evagora condignella* Bsk., paratype, female, Valparaiso, Fla.
12. *Eucordylea* sp., male, Round Hill, N.S.
13. *Exoteleia pinifoliella* Chamb., female, Ottawa, Ont.
14. *Exoteleia* sp., female, Toronto, Ont.
15. *Exoteleia dodecella* Linn., male, Vernon, Ont.
16. *Chionodes retiniella* B. and Bsk., male, Elko, B.C.
17. *Zelleria hainbachii* Bsk., male, Constance Bay, Ont.
18. *Argyresthia flexilis* n. sp., holotype, male, St. Marys, Mont.
19. *Argyresthia pilarella* Brn., topotype, male, San Francisco, Calif.
20. *Argyrotaenia pinatubana* Kft., male, Ottawa, Ont.
21. *Ocnerostoma piniariellum* Zell., male, East Glacier, Mont.
22. *Ocnerostoma strobivorum* n. sp., holotype, male, Constance Bay, Ont.
23. *Epimotia aridos* n. sp., holotype, male, East Glacier, Mont.
24. *Argyrotaenia tabulana* Free., holotype, female, Constance Bay, Ont.

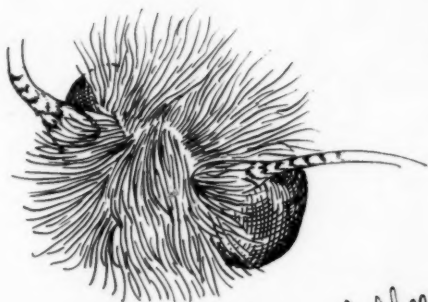




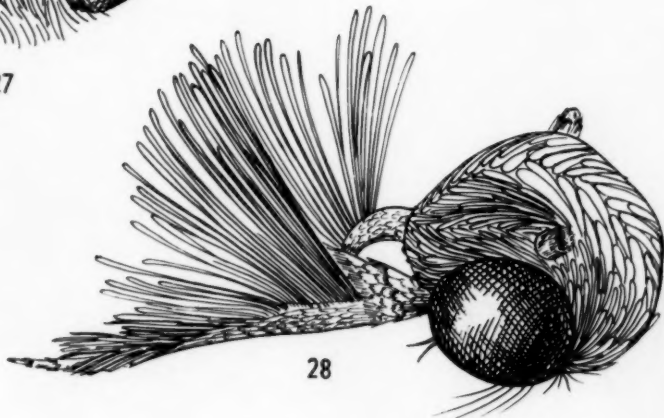
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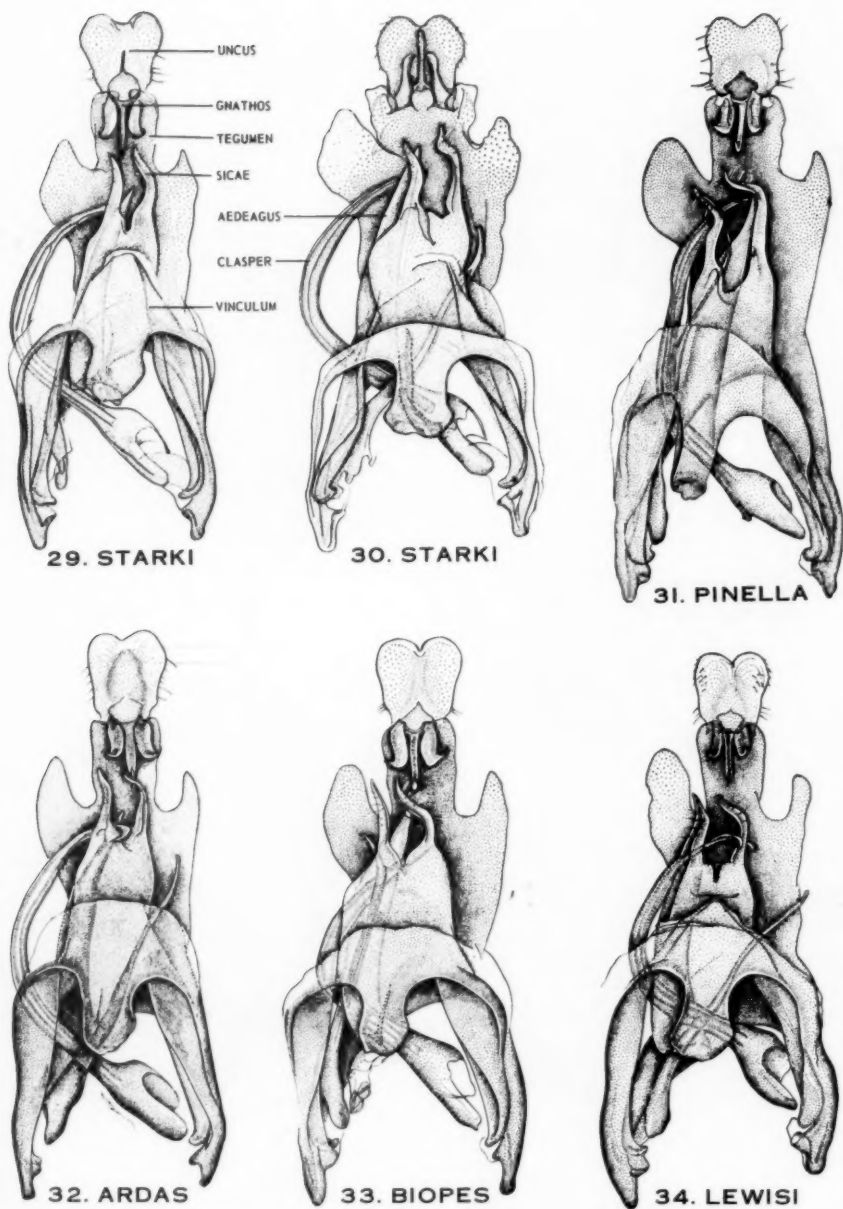


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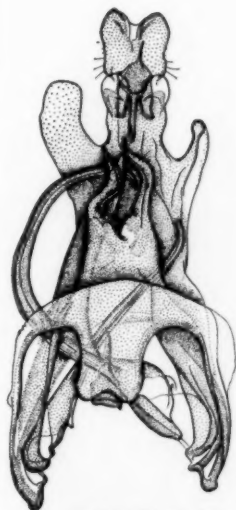


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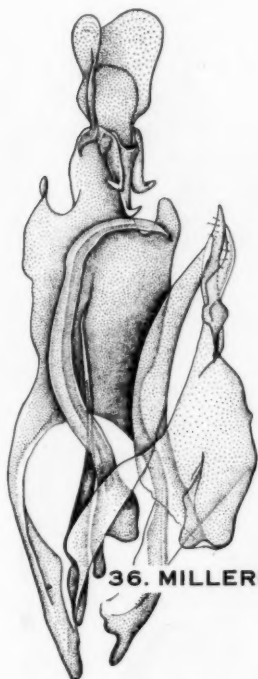
Figs. 25-28. Adult heads; 25, *Exoteleia dodecella* Linn.; 26, *Argyrotaenia tabulana* Free.; 27, *Ocnerosstoma piniariellum* Zell.; 28, *Eucordylea* sp.



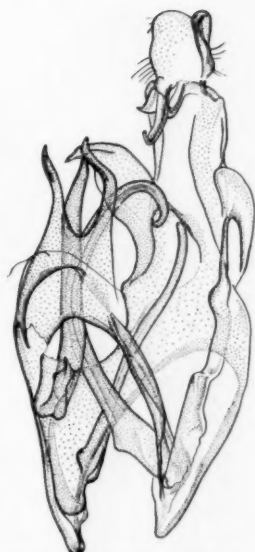
Figs. 29-34. Male genitalia of *Evagora*.



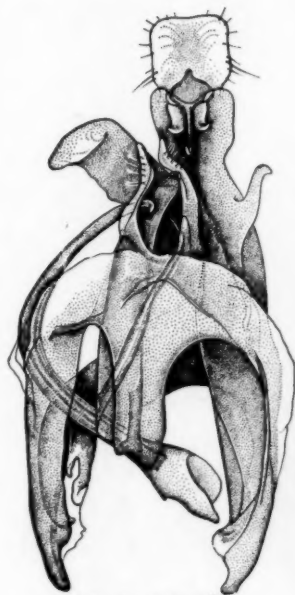
35. RESINOSAE



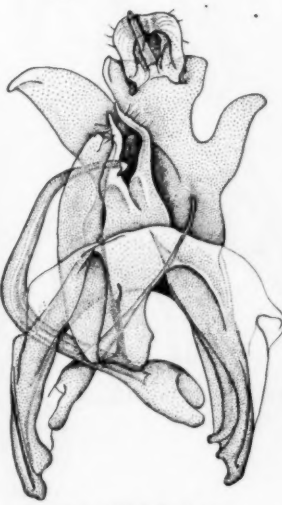
36. MILLERI



37. MOREONELLA



38. FLORAE

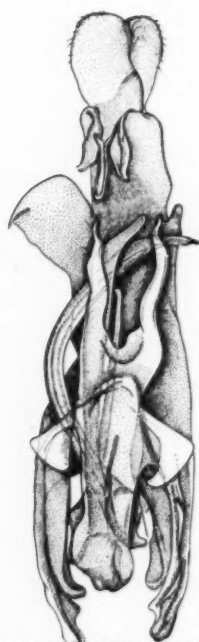


39. FLORAE

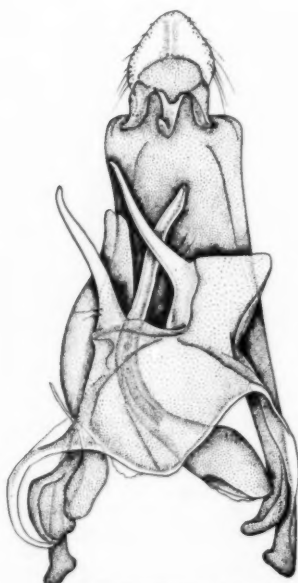


40. FLORAE

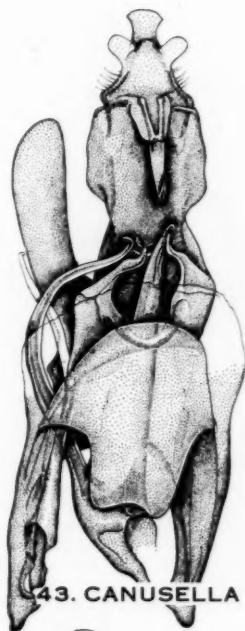
Figs. 35-40. Male genitalia of *Evagora*.



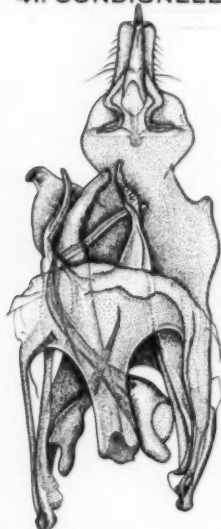
41. CONDIGNELLA



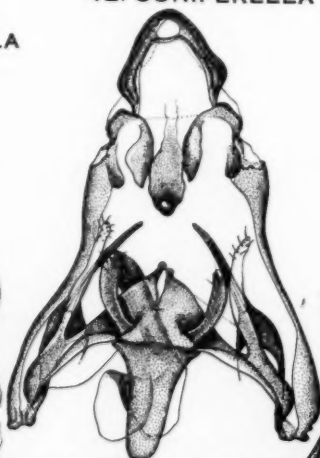
42. CONIFERELLA



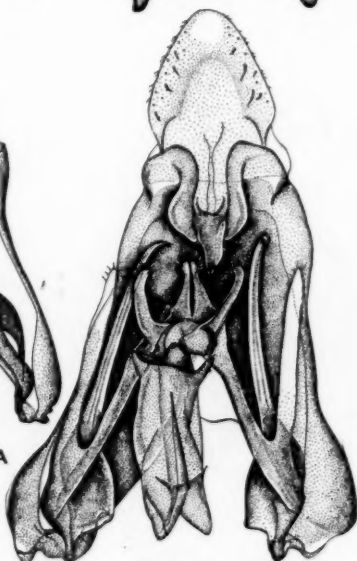
43. CANUSELLA



44. ATRUPECTELLA

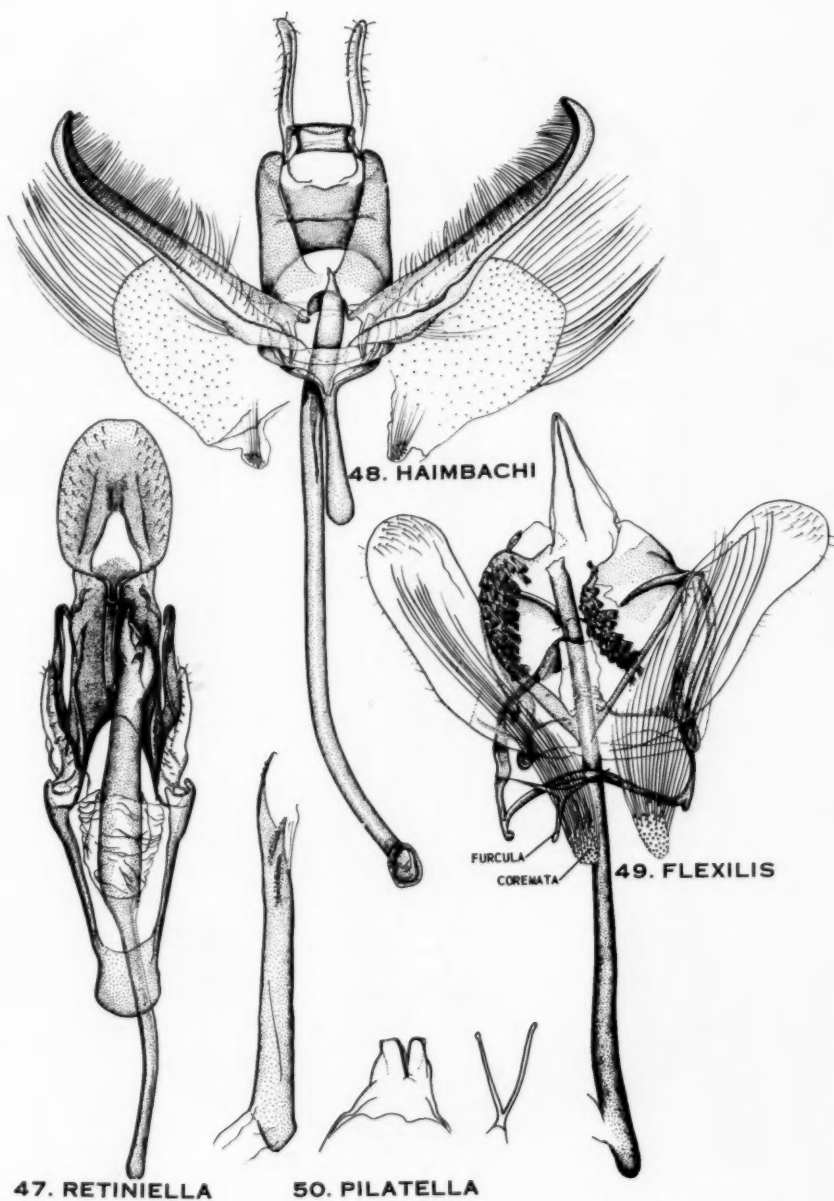


45. PINIFOLIELLA

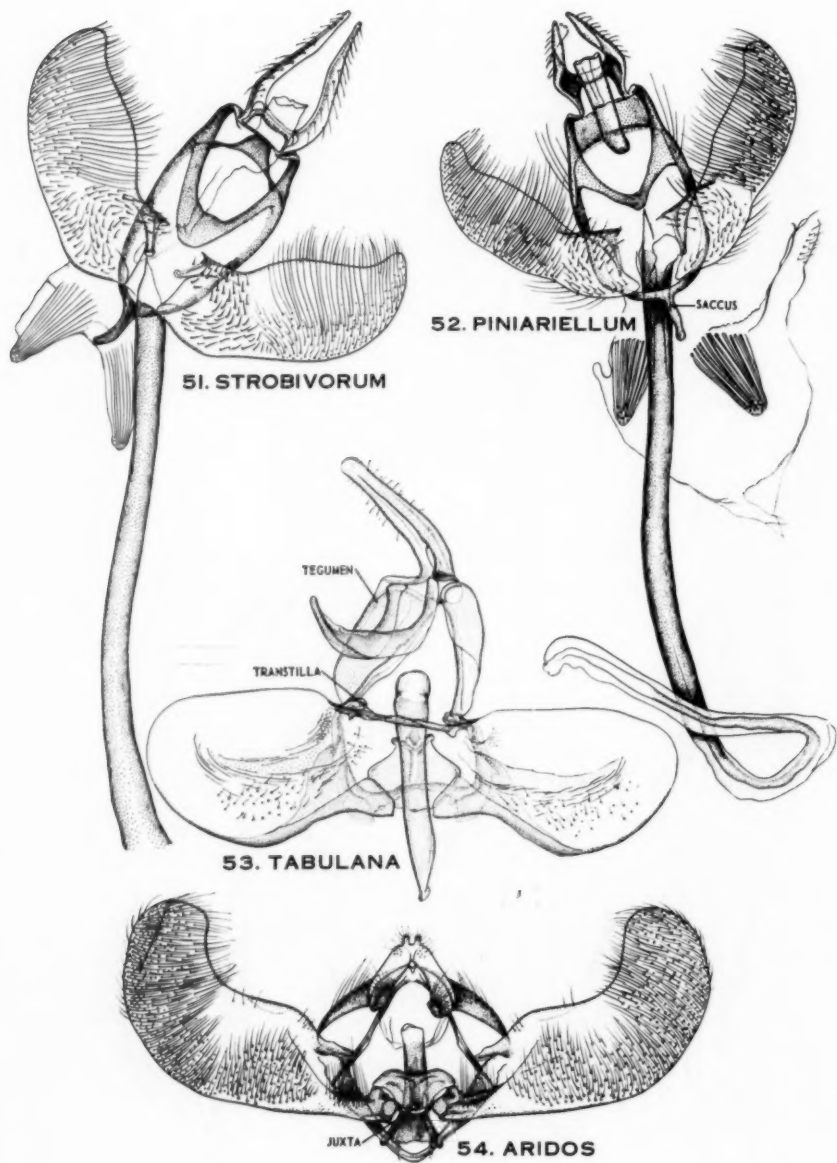


46. DODECELLA

Figs. 41-46. Male genitalia; 41-43, *Evagora*; 44, *Eucordylea*; 45, 46, *Exoteleia*.



Figs. 47-50. Male genitalia; 47, *Chionodes*; 48, *Zelleria*; 49, 50, *Argyresthia*.



Figs. 51-54. Male genitalia; 51, 52, *Ocnerostoma*; 53, *Agryrotaenia*; 54, *Epinotia*.



55 STARKI

56 ARDAS

57 BIOPEs

Figs. 55-57. Needles mined by *Evagora* spp.



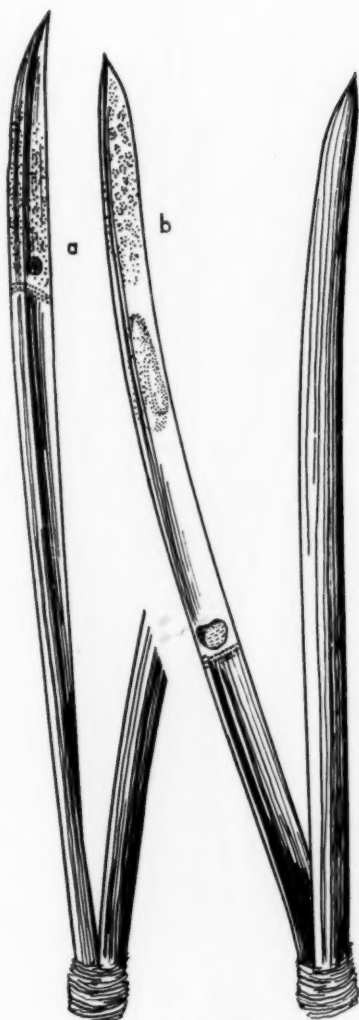
Figs. 58-60. Needles mined by *Evagora* spp



Fig. 61. Needles mined by *Evagora florae* Free.



Fig. 62. Needles mined by *Evagora canusella* Free.



63 PINIFOLIELLA



64 DODECELLA

Figs. 63-64. Needles mined by *Exoteleia* spp.

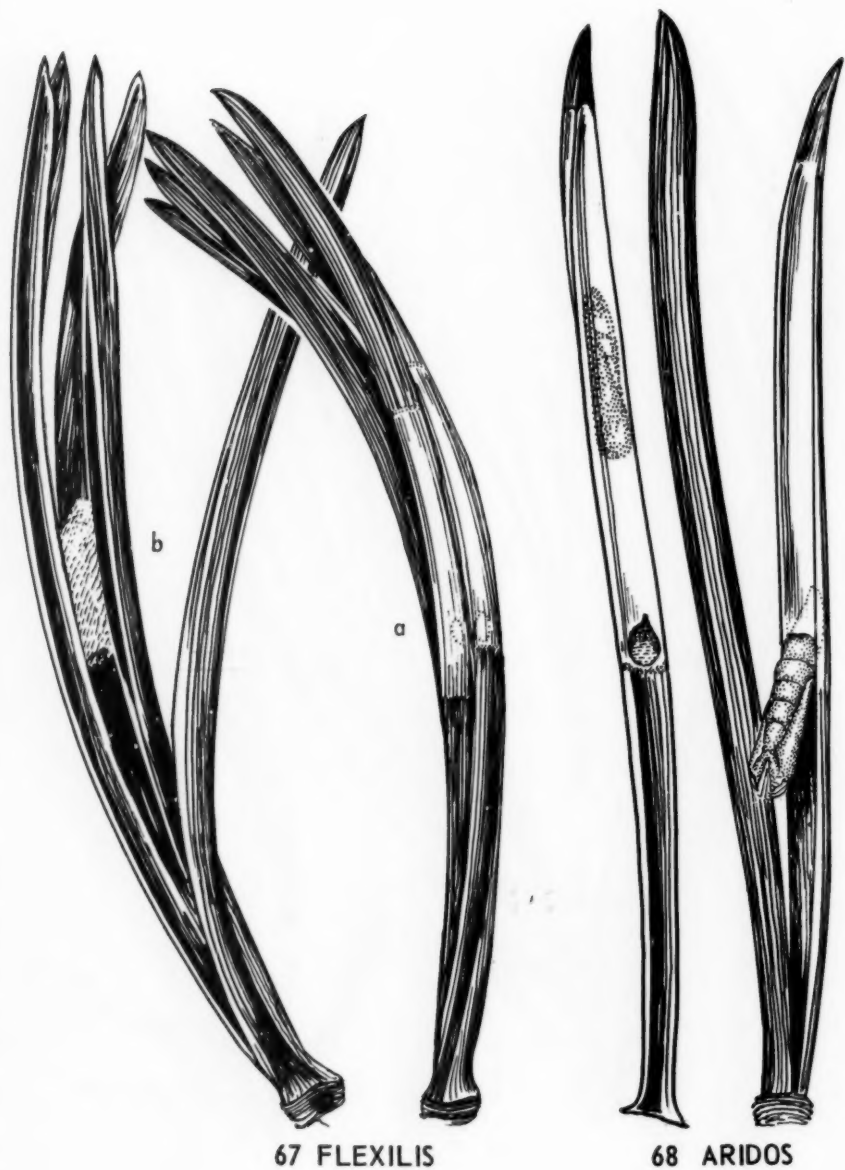


65 RETINIELLA

Fig. 65. Needles mined by *Chionodes retiniella* B. and Bsk.



Fig. 66. Needles damaged by *Zelleria haimbachi* Bsk.



Figs. 67-68. Needles mined by *Argyresthia flexilis* Free., and *Epinotia aridos* Free.



69

PINATUBANA

Fig. 69. Needles mined and eaten by *Argyrotaenia pinatubana* Kft.



Figs. 70-71. Needles mined by *Ocnerosstoma strobivorum* Free. and *O. piniariellum* Zell.

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